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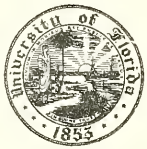

Suggested Unit Course in

CONCRETE FORM CONSTRUCTION

Carpentry Series

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The carpentry series includes five well-illustrated modern texts designed for carpentry students, apprentices, home workshop hobbyists, home owners, craftsmen, construction foremen, and teachers.

The text material is arranged in the order in which the related trade theory units are learned and fundamental carpentry operations performed in the erection of light frame buildings.

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by J. Douglas Wilson and S. O. Werner

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57 pages + v pp. (7¾ x 10¼); 34 line drawings

PREFACE

Increased demands for industrial and domestic building construction, and the shortage of skilled carpenters, has created a need for well organized instructional material for industrial-technical training programs. In addition, with the lifting of restrictions on the procurement of building materials, many home owners are confronted with the problem of performing basic woodworking operations for the upkeep and maintenance of personal property.

Careful analyses were made over a period of years to determine what the essential occupational areas of the carpentry field include. As a result, four main divisions of the trade were defined and texts were prepared to cover: (1) Hand Tools and Portable Machinery; (2) Concrete Form Construction; (3) Framing, Sheathing and Insulation; and (4) Interior and Exterior Trim.

The selected instructional units in each of the four texts include only basic and fundamental operations common to a specific branch of carpentry work. Further study revealed that each operation involves the teaching of basic trade theory and fundamental processes. In accordance with this line of reasoning, a *Trade Theory Series* and an accompanying *Fundamental Process Series* of instructional units are included in each book.

Trade Theory Series

Related technical information such as principles governing carpentry practices, computations, and descriptions of tools and materials are covered in the *Trade Theory Series*. This technical information also serves as a reference for the student by supplying him with the trade knowledge necessary to perform carpentry operations skillfully.

Fundamental Process Series

Each step involved in the actual performance of an operation that requires the use of hand tools, measuring tools or portable machinery is fully described in common trade terminology and well illustrated with line drawings in the *Fundamental Process Series*. The term *Fundamental Process* is used because the processes which constitute an operation are common to carpentry work in any situation. The *Fundamental Process* units serve as reference material for the actual performance of operations and may be used to supplement the teaching of operations whether they be on the job or in a school or industrial shop.

The instructional units appear in the sequence generally followed in erecting light frame buildings. Under actual training conditions the order may be changed to meet exacting course requirements for a locality without affecting the efficiency of the material.

* * * *

Grateful acknowledgment is made to the Bureau of Industrial and Technical Education, The New York State Education Department, for permission to reprint this instructional material.

The Editor

Albany, New York
August, 1946

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Carpentry Series

CONCRETE FORM CONSTRUCTION

TABLE OF CONTENTS

Units of Instruction

Trade Theory Series		*Fundamental Process Series*	
Unit	*Pages*	*Unit*	*Pages*
1C-T20 Description of Soil Conditions Encountered in Foundation Work	1 to 4	1C-P20 How to Determine Soil Conditions for Foundation Work	5 to 7
1C-T21 Principles of Laying Out Building Lines	8 to 9	1C-P21 How to Lay Out Building Lines	10 to 13
1C-T22 General Information About Concrete Form Construction	14 to 16	1C-P22 Omitted—See Unit 1C-T22	
1C-T23 Description of Materials Used in Form Construction	17 to 23	1C-P23 How to Use Materials in Form Construction	24 to 29
1C-T24 Description of Anchor Bolts in Form Construction	30 to 31	1C-P24 How to Suspend Anchor Bolts	32 to 35
1C-T25 Description of Forms for Concrete Piers and Wall Footings	36 to 43	1C-P25 How to Construct and Set Forms for Piers and Footings	44 to 52
1C-T26 Description of Forms for Concrete Foundation Walls	53 to 54	1C-P26 How to Build Forms for Foundation Walls	55 to 64
1C-T27 Description of Openings in Concrete Walls	65 to 66	1C-P27 How to Provide for Openings in Concrete Walls	67 to 72
1C-T28 Description of Forms for Concrete Steps	73 to 76	1C-P28 How to Build Forms for Concrete Steps	79 to 87
1C-T29 Description of Forms for Floor and Sidewalk Slabs	88 to 89	1C-P29 How to Build Forms for Concrete Floors and Walks	90 to 93
1C-T30 Description of Forms and Centers for Arched Openings	94 to 98	1C-P30 How to Lay Out and Build Centers for Arched Forms	99 to 105

Bibliography 106

DESCRIPTION OF SOIL CONDITIONS ENCOUNTERED IN FOUNDATION WORK

OBJECTIVES OF THE UNIT

1. To acquaint the learner with types of soils suitable for good foundation footings.

2. To acquaint the learner with soil conditions unsuitable for good foundation footings.

3. To explain some of the precautions to be taken in locating footings.

INTRODUCTORY INFORMATION

The most important consideration in the locating of footings is the character of the soil on which they are to rest. Since the earth is made up of different types of strata or soils, consideration must be given to their suitability as a foundation base. Tests made every ten feet will show definitely the character of the soil upon which the entire foundation of the building is to rest.

TYPES OF SOIL

The soil or strata generally encountered in small building foundations may be classified into three divisions; rock, virgin soil, and fill.

A. ROCK

Rock is the best foundation upon which to build, provided that it is made level. Otherwise, it must be stepped up with concrete to a level footing. The rock should underlie the whole foundation.

B. VIRGIN SOIL

Virgin soil is clay, gravel, loam, sand, or marshy ground in its natural condition.

Gravel, when compact and mixed with sharp sand to form a firm and unyielding stratum, is known as hard pan. This makes an excellent foundation.

Clay is the most uncertain of soils because of its elasticity. This is due to the fact that it is mixed with marl, water, and other substances. In dry seasons, it is very firm while in wet seasons it becomes very slippery and unreliable. Clay is usually found in layers extending over a large area.

Loam, when mixed with other earthy substances, and when compact and of considerable depth, is a good foundation soil.

Sand is formed by the decomposition of rocks. It is generally found in beds which were, at one time, river beds. It is not a good foundation soil unless it is well confined and well drained. Quick-sand is a very fine sand mixed with loamy material which retains a large quantity of water. It is a very poor foundation soil as it will flow into the excavation as fast as it can be dug out. Quick-sand may be prepared for foundations, but this is an expensive operation.

Marshy soils are formed by the decay of plants and other vegetable matter in sluggish water. Since there is no current, the plants take root in the bed. Successive beds of decayed plants are formed under slight pressure, and small cavities are formed. In some cases, these beds have become so deep that their bottoms have never been reached. This type of soil is sometimes called bog or swamp and is very dangerous as a foundation soil.

C. FILL

Made or artificial soil is often found in subdivisions or where depressions in the earth have been filled with refuse or city dumpings. It should not be built upon until the excavation is cleaned of the poor fill, and the proper soils on which to rest the footings are reached.

BEARING STRENGTH OF SOILS

Foundation Soils	Per Square Foot
Rock, granite	30 tons
Limestone (compact)	25 tons
Shale (soft rock)	8 to 10 tons
Gravel (dry coarse)	6 tons
Gravel (soft ")	4 to 6 tons
Clay (dry thick beds)	4 tons
Clay (dry soft ")	1 to 1½ tons
Sand (clean, dry and confined)	2 tons
Earth (solid and dry (natural)	4 tons

FROST LINE IN RELATION TO SOIL AND PIER FOOTINGS

A common cause of foundation movement is the failure to place the footings below the frost line. If the temperature drops to below freezing before the water drains from the soil, the frost penetrates the soil deeply, thus freezing the water in the soil to a considerable depth. The resulting expansion of the soil under frost pressure

causes heaving. Water helps carry the frost line down into the earth. If the water drains from the soil rapidly, the frost cannot penetrate the ground very far. A good example of this is under a porch where the ground is dry. Even in zero weather, the top of the soil will not be frozen as long as it is dry. It will heave and harden under freezing conditions, according to the amount of moisture it contains.

In most cities the building code assumes a depth of frost line for that community. Twenty to thirty inches below the surface is considered safe in most cases.

DETERMINING SOIL CONDITIONS

In placing footings for foundations, the type of soil on which the footings are to rest must be considered. The size of the footing depends on the bearing strength of the soil. The bearing strength of the soil in turn depends on the surrounding soil conditions such as water drainage and type of soil above and below the footing. For these reasons, the soil below the surface of a building site should be examined.

There are several methods of determining soil conditions. The open pit method consists of digging a pit at the approximate location of the proposed foundations and to a depth below the frost line where a good foundation soil is reached. By observing the side wall of the pit, the location and type of each layer of soil may be studied and classified as to its suitability as a foundation soil. This method is used to determine if drainage of the surrounding soil is necessary, and how deep the footing must be placed so it will rest on a good foundation soil. It will then be possible to determine the size of pier that is necessary to carry the proposed load.

DRAINAGE OF WATER FROM FOUNDATION SOILS

Surface water seeps into the ground until it strikes a layer of clay. It then flows along the top of the clay along the natural slope, forming a slippery surface. A footing placed on the clay is likely to move if enough surface and sub-surface water flows along the bed of clay. For this reason, soils surrounding foundations should be drained of excessive water. In the construction of military housing foundations, where many piers are needed for a single building, it is better to drain the outside of the whole foundation of sub-surface water, rather than to drain each pier separately.

No matter how carefully a foundation is built, it is likely to shift if water is not prevented from accumulating in the foundation. bed.

SELECTED REFERENCES

I.C.S. Reference Library, Vol. 158 .... International Correspondence School

Recommended Minimum Requirements for Small Dwelling Construction ..... U.S. Department of Commerce

HOW TO DETERMINE SOIL CONDITIONS FOR FOUNDATION WORK

OBJECTIVES OF THE UNIT

1. To show how to determine soil conditions on the building site.
2. To show how to drain water from foundation footings.

INTRODUCTORY INFORMATION

The principles involved in good foundations for light frame construction should concern the carpenter who builds forms for footings, piers and walls. This does not necessarily mean that this type of work should fall in the province of carpentry work, but the carpenter with a general knowledge of soil conditions often can prevent the improper placement of footings.

TOOLS AND EQUIPMENT

Long-handled shovel
Pickaxe
Steel tape
Crowbar

PROCEDURE

HOW TO TEST SOILS BY THE OPEN PIT METHOD

1. Dig a square pit about two feet larger than the proposed concrete pier. The pit should be deep enough to reach good foundation soil below the frost line of the locality (Fig. 1).

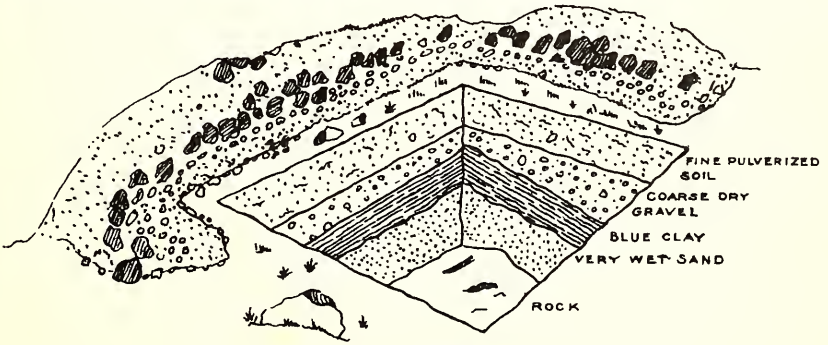

FIG. 1

PIT METHOD OF DETERMINING SOIL CONDITIONS

2. Observe the sides of the pit and note if there are any layers of soil that will shed surface and subsurface water into the pit. Such a layer is shown in Fig. 2 where the footing rests on a layer of blue clay and the subsurface water flows into the footing bed.

   NOTE: If this condition is found, the excavation should be drained as shown in Fig. 3.

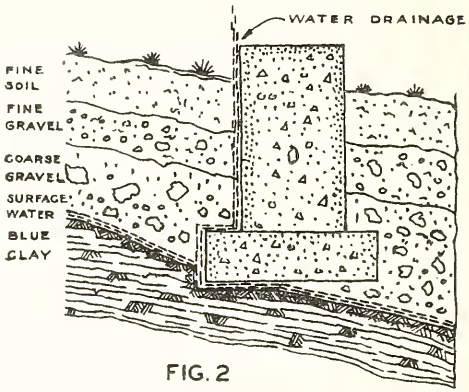

FIG. 2

FLOW OF WATER AT PIER FOOTING

3. Examine the soil at the bottom of the pit and classify it according to its bearing strength. See Unit 1C-T20. The size of the foundation or pier will be determined by the bearing strength of the soil and the load to be imposed on the foundation.

HOW TO DRAIN WATER FROM FOOTINGS

NOTE: In Fig. 3, a trench one foot wide has been allowed on the outside of the wall or pier.

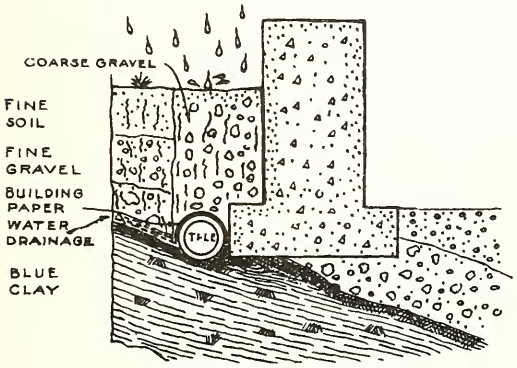

FIG. 3

DRAINAGE OF WATER

1. Place drain tiles at the bottom of this trench and slope the tiles to a point outside the foundation. Lay them with an opening of about one half inch at the joints.

2. Embed the bottom of each joint in cement and cover the top of each joint with building paper.

3. Fill the trench with coarse gravel to within about six inches of the grade line. Cover the gravel with top soil.

HOW TO DRAIN A GROUP OF PIER FOOTINGS

1. Dig a trench around the outside of the pier footings as shown in section in Fig. 3 and in plan in Fig. 4.

   NOTE: In building sites where the amount of water is excessive, drain tiles should be laid diagonally under the foundation. Care must be taken that the drain tiles do not run underneath a pier footing.

2. Lay the tile as directed for wall footings, and slope the tile to a catch basin outside the foundations.

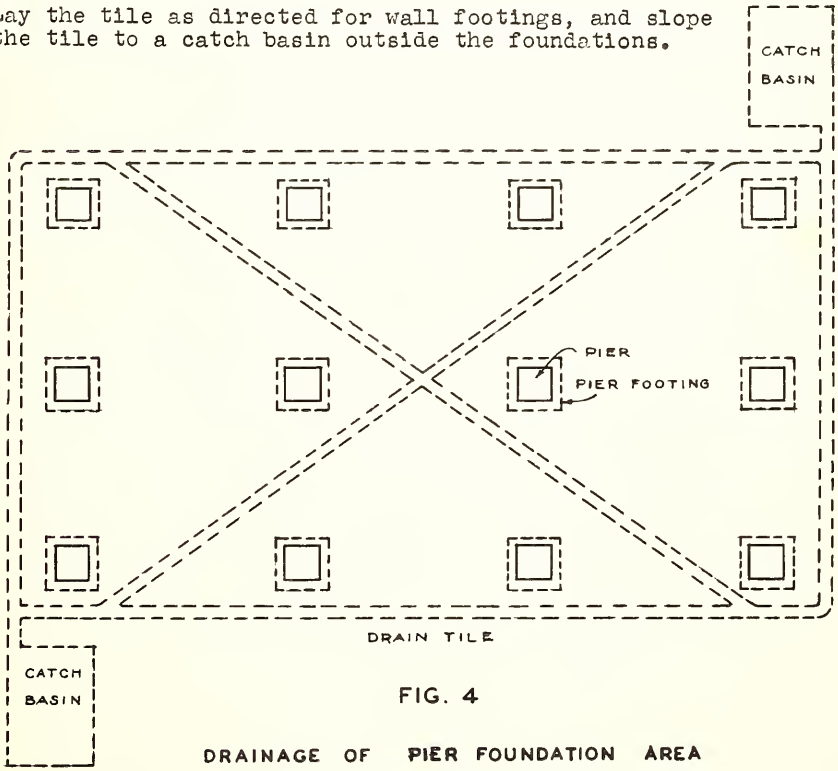

FIG. 4

DRAINAGE OF PIER FOUNDATION AREA

PRINCIPLES OF LAYING OUT BUILDING LINES

OBJECTIVES OF THE UNIT

1. To acquaint the learner with the sources of information needed to establish building lines.

2. To acquaint the learner with the method of establishing building lines.

3. To acquaint the learner with the method used to check for squareness of corners, using the 6-8-10 rule.

INTRODUCTORY INFORMATION

The carpenter is often called upon to lay out excavation lines, using the lot lines, the building code, and special restrictions as guides. Before building lines are established, the lot should be surveyed by a registered surveyor. Existing lot lines or stakes should not be depended on unless they have been checked by the surveyor.

BUILDING LINES

The builder should find out from the building code of the community and the map of the section, if there are any restrictions concerning the location of the building on the lot. A knowledge of the grade line established at that particular lot is also necessary to place the footings of the foundations at the proper levels.

Some builders use temporary stakes on which to stretch lines showing the outline of the excavation. This may answer the purpose for approximate work but it is better practice to erect batter boards carefully at the corners of the excavation. They should be placed far enough away from the excavation so as not to interfere with the digging. They should be well braced and the cross bars should afford reliable work points on which to stretch lines indicating the outside line of the excavation, and the outside and inside of the masonry wall or concrete forms. The tops of the batter boards are sometimes notched to show these points so that the lines may be taken down and replaced in the same locations. The boards may be leveled to coincide with some point on the finished wall, such as the top of the wall, or the first floor line of the building.

The easiest, quickest and most accurate way to determine the building lines of a new building is to use a builder's transit as described in Unit 1C-T3. When such an instrument is not available, square corners may be laid out by means of the 6-8-10 rule together with batter boards at each corner of the excavation. This rule is

based on the fact that a triangle whose sides are exactly 6, 8 and 10 feet long is a right angle triangle, the angle opposite the longest side being a 90° angle (Fig. 1).

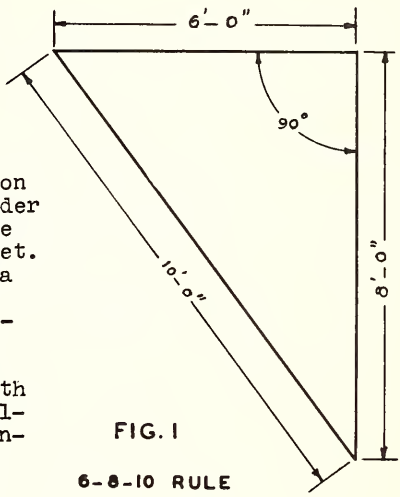

FIG. 1

6-8-10 RULE

LEVELS

If there is to be a cellar excavation and if the house sewer line is to be under the cellar floor, it is well to know the elevation of the sewer line of the street. The cellar floor then can be placed at a higher level than the street sewer to afford proper sewer drainage. Grade elevations should be established at the time of laying out the foundations, and should be kept in reasonable harmony with the adjacent property and street curb elevation. Otherwise, surface water drainage from one parcel of land to another might result.

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Carpentry and Joinery Work ..... Nelson L. Burbank

The Principles and Practice of Surveying, Vol. 1.... Breed and Hosmer

Audels Carpenters and Builders Guide #3 ..... Graham and Emery

HOW TO LAY OUT BUILDING LINES

OBJECTIVES OF THE UNIT

1. To show how to erect batter boards for building layout lines.
2. To show how to suspend layout lines from batter boards.
3. To show how to square up layout lines at corners and check layout for squareness.
4. To show how to lay out footing locations from a layout line.

INTRODUCTORY INFORMATION

It is of great importance in the layout of building lines that the work be checked and rechecked, and that the dimensions shown on the drawings prove themselves. This procedure can best be accomplished by erecting rigid batter boards and by checking all measurements from lot lines established by a registered surveyor.

TOOLS AND EQUIPMENT

Spirit level
Line level
Layout line
Hammer or sledge
Nails (8d)
Two steel tapes
Crosscut saw

PROCEDURE

1. Establish a base line from the surveyor's lines to mark out one end of the building. See line AB, Fig. 1. Set stakes locating the two corners at A and B on this line.
2. Drive a nail in the center of the top of each of these stakes to locate the corners accurately.
3. On the line AB drive a stake F, 6 ft. from stake A. Drive a nail in the top of this stake exactly 6 ft. from the nail in stake A.
4. Drive stake E so a nail driven in the top will be exactly 8 ft. from the nail in stake A and exactly 10 ft. from the nail in stake F. The corner (EAF) will then be a right angle.
5. With a steel tape, lay out the length of the building along line AE extended to D which will be the third corner. Drive a stake at this point. A nail driven in the top of this stake should accurately mark the end of the boundary line AD.
6. Hook the end of a steel tape on the nail on stake D and lay off the width of the building toward C.

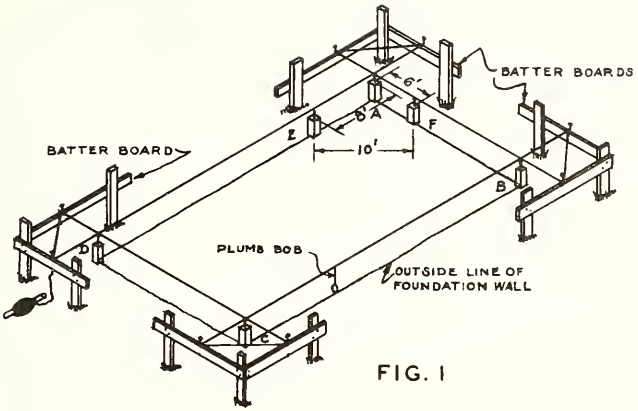

FIG. 1

LAYOUT OF BUILDING LINES

7. Hook the end of another steel tape over the nail on stake B and measure the length of the building toward C. When both steel tapes are pulled taut and the points on the tapes showing the length and width of the building coincide, the point C will be accurately located. Drive a stake at this point and drive a nail in the top of the stake accurately locating this point.

8. Erect batter boards at the four corners but far enough away so they will not be disturbed by the excavating (Figs. 1 and 2). Set the tops of the batter boards at first floor level or at some other convenient point.

   NOTE: In establishing the elevation of any part of the foundation, the top of the curb stone of the street may be used as a reference point. If there is no curb, the surveyor should establish that elevation to govern the location of the top of the batter boards. A carpenter's leveling stand is sometimes used to transfer the curb level to one batter board.

9. Stretch lines above the nails in stakes A,B,C and D, Fig. 1 and fasten them to nails driven in the batter boards.

10. Test the squareness of the corners by the 6-8-10 method explained in Unit 1C-T21. Test the complete layout by measuring the diagonals with a steel tape (Fig. 2). If the diagonals are equal in length, the corners are square.

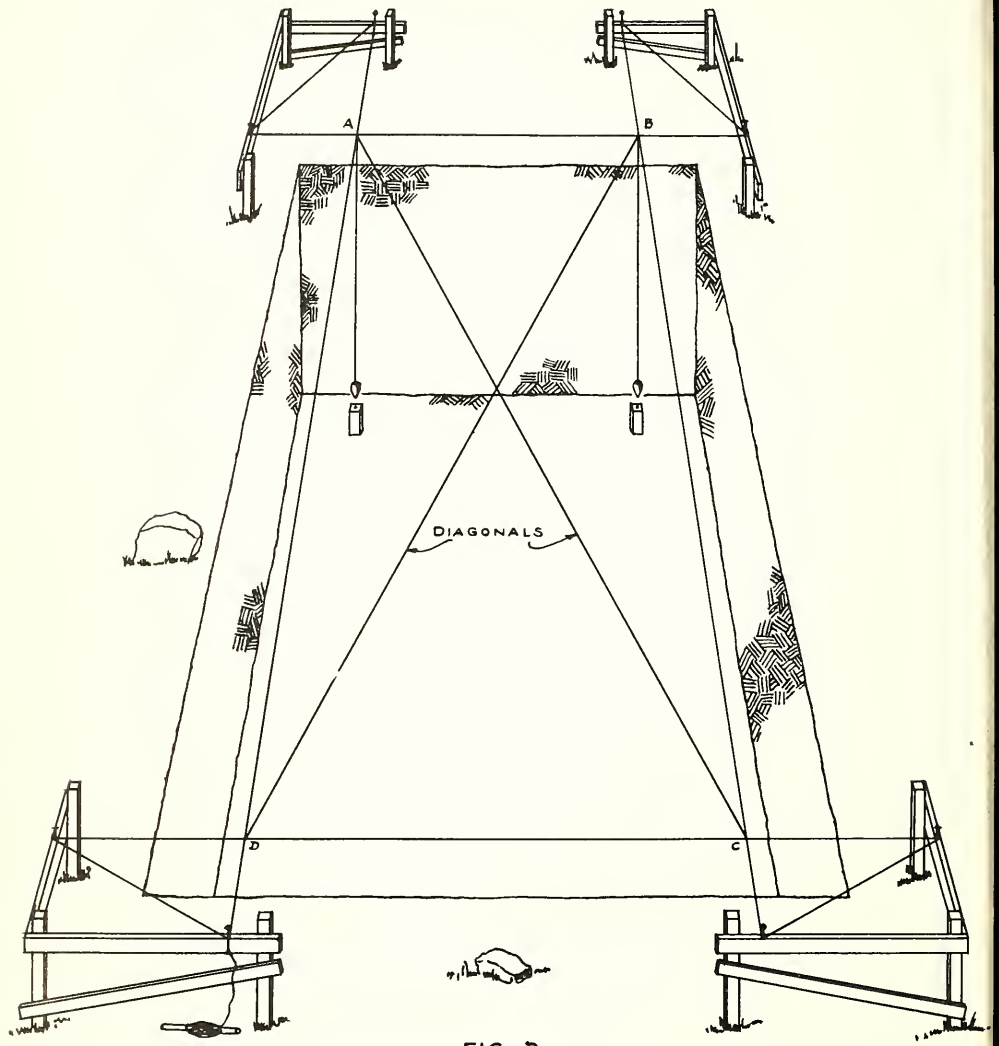

FIG. 2

LOCATING BUILDING LINE CORNERS AT BOTTOM OF EXCAVATION

11. After the batter boards have been set in position and after the lines indicating the layout of the building have been transferred to them, remove the corner stakes (A,B,C and D, Fig. 1).

12. To locate points from the suspended lines to the surface of the ground or to the bottom of an excavation, use a plumb-bob as shown in Fig. 1. In this case the outside foundation line is located from the suspended line. In Fig. 2 the corner stakes at the bottom of the excavation are located in the same manner.

TO ESTABLISH LEVELS FOR FOUNDATIONS

The use of the builder's level or transit to locate levels in relation to the surveyor's bench mark is explained in Hand Tools and Portable Machines, Unit 1C-P3.

GENERAL INFORMATION ABOUT CONCRETE FORM CONSTRUCTION

OBJECTIVES OF THE UNIT

1. To describe the function of each member of a concrete form.

2. To acquaint the learner with types of forms for single use, and with standardized forms for re-use.

3. To acquaint the learner with some of the precautions to be taken in building concrete forms.

INTRODUCTORY INFORMATION

Wooden forms are built for concrete footings, piers, walls, and other concrete masses. These forms must be built in such a manner that they will hold and support the semi-liquid concrete until it has hardened. The forms are usually temporary, and the materials may be used again after they have been removed from the hardened concrete.

FUNCTION OF CONCRETE FORM MEMBERS

The tongue and groove sheathing (Fig. 1) forms a water tight enclosure and provides a smooth surface against which the poured concrete can rest until it has hardened. Plywood is used on curved surfaces instead of tongue and groove sheathing.

The shoe acts as a plate to hold the studs at equal spacing and as a straight edge to the form.

The studs form a solid backing for the sheathing and hold it in alignment.

The walers hold the panels of the form in a straight line and provide rigidity and bracing.

The spreaders hold the forms the proper distance apart until the concrete has been poured.

The wires hold the panels against the spreaders, thus keeping the forms from spreading apart under the pressure of the semi-liquid concrete. The wires are twisted to draw and hold panels tightly against the spreaders.

The braces hold the form in an upright or solid position and prevent the form from moving under the pressure of the wet concrete.

The stakes give nailing support for the braces.

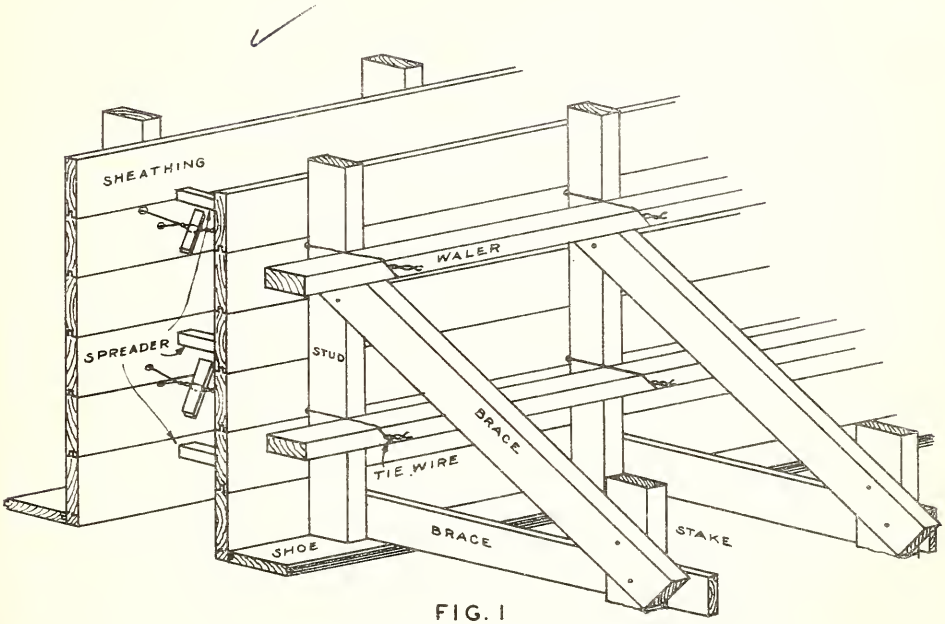

FIG. 1

FORM FOR A CONCRETE WALL

FORMS FOR SINGLE USE

When the forms are to be used for only one foundation, and the form material is to be re-used in other parts of the building, the studs and walers are not cut to length but are left in stock lengths. The sheathing is nailed only enough to hold it in place. It can then be easily taken apart. After the walls have been stripped, the lumber should be cleaned of cement and piled in such a way as to prevent it from warping.

FORMS TO BE USED MORE THAN ONCE

Forms are sometimes made up in standard size panels. This method is used where there are many foundations of a similiar size to be built. The panels are made in lengths of from 2 to 12 ft. and in widths of from 4 to 6 ft. depending on the size of the wall. The use of these panels saves time in erecting the forms.

It will require thought and ingenuity on the part of the carpenter to plan efficient and economical forms. They should be made in sections

that can be handled and set without difficulty and that can be fastened at the joints so they may be taken apart without breaking.

After the wooden forms have been built to the required measurements, they should be oiled to provide a smooth surface on the face of the concrete wall and to prevent the moist concrete from soaking into the pores of the wooden forms, causing the forms to stick to the hardened concrete wall and making the stripping more difficult.

After the forms have been set in the proper place, they should be fastened together, plumbed and braced on the corners, squared, and then aligned. In setting the forms, temporary braces should be put in place to hold the form straight until walers and braces can be properly secured.

After the forms have been removed from the hardened concrete, they should be carefully repaired where needed. If they are not to be set up at once, they should be stored for future use.

PRECAUTIONS TO BE TAKEN IN FORM WORK

The forms should be tight to prevent leakage of the liquid concrete through the joints of the sheathing. If the forms are not tight, ridges will be formed on the surface of the concrete wall, thus making extra work in finishing the wall. Ridges on the wall also make stripping of the forms difficult.

The carpenter should examine the forms and their supports to detect any defects or weakness before the concrete is poured into the forms. There should be a constant check made on the braces while the concrete is being poured because, as the forms are filled, the pressure within them increases.

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Concrete on the Farm ..... The Atlas Portland Cement Co.

Alpha Cement - How to Use It ..... Alpha Portland Cement Co.

A Vocational Course in Concrete ..... Portland Cement Association

DESCRIPTION OF MATERIALS USED IN FORM CONSTRUCTION

OBJECTIVES OF THE UNIT

1. To describe the stock sizes of lumber used in form construction.
2. To describe the various metal ties, spreaders, and fasteners used in form construction.
3. To describe methods of estimating quantities of lumber for forms.

INTRODUCTORY INFORMATION

Various kinds of wood are used in building forms but the kind used in a particular case usually depends on the lumber dealer's stock on hand. However, soft wood is most commonly used. In the East, fir and hemlock are generally used for studding and walers, while on the South and West, very little hemlock is used.

Special plywoods made to resist moisture are used to some extent where the finished wall is to be free from firs or other irregularities. Because of its superior strength, its waterproof qualities, and the low cost of application, this special plywood is becoming popular for form construction.

Combination wall ties and spreaders are manufactured in accordance with the standard sizes of studding, walers and sheathing. Therefore, when stock lumber is used, the wall ties will be the correct length when in place.

STANDARD SIZES OF FRAMING LUMBER

Nominal Size	Actual Size
2" x 4"	1 5/8" x 3 5/8"
2" x 6"	1 5/8" x 5 5/8"
2" x 8"	1 5/8" x 7 1/2"
2" x 10"	1 5/8" x 9 1/2"
2" x 12"	1 5/8" x 11 1/2"

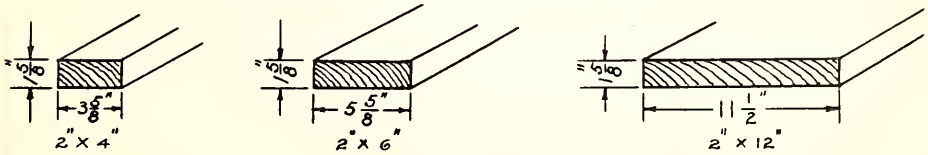


FIG. 1

STANDARD SIZES OF FRAMING LUMBER

STANDARD SIZES OF TONGUE AND GROOVE SHEATHING

Nominal Size Thickness	Face	Actual Size Thickness	Face
1"	x 4"	25/32"	x 3 1/4"
1"	x 6"	25/32"	x 5 1/4"
1"	x 8"	25/32"	x 7 1/4"
1"	x 10"	25/32"	x 9 1/4"

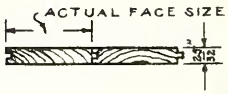


FIG. 2
TONGUE AND GROOVE SHEATHING

STOCK SHIPLAP SIZES

Nominal Size Thickness	Face	Actual Size Thickness	Face
1"	x 4"	25/32"	x 3 1/8"
1"	x 6"	25/32"	x 5 1/8"
1"	x 8"	25/32"	x 7 1/8"
1"	x 10"	25/32"	x 9 1/8"

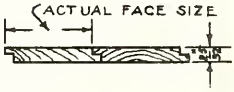


FIG. 3
SHIPLAP SHEATHING

PLYWOOD PANELS

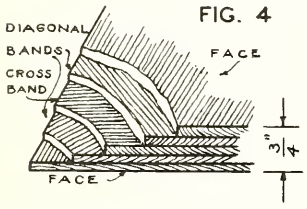


FIG. 4
FIVE PLY PLYWOOD

Plywood panels may be secured in thicknesses of 1/8", 1/4", 3/8", 1/2", 5/8", and 3/4". These thicknesses are generally made up of three or five plies. These plies, in the type of plywood used for form construction, are held together by waterproof glue. The panels are 4 ft. wide and range from 4 to 12 ft. in length.

Masonite is another comparatively thin smooth material used for form covering. Both Masonite and plywood should be backed up as shown in Fig. 7. Masonite, being flexible, requires more nailing than plywood.

SPREADERS AND FASTENERS

Various types of combination metal wall ties and spreaders are used in form construction. The new type of rods with spreader washers set for the width of the wall, eliminates the necessity of using wood spreaders and saves considerable time in form building. The tie rods are drawn tight by means of metal wedges which can be tightened or

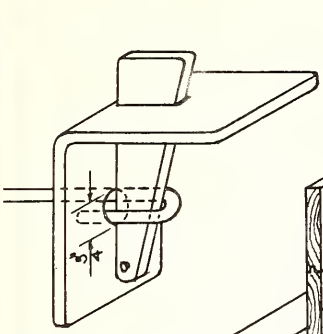


FIG. 5B

ENLARGED VIEW OF WEDGE TIGHTENER

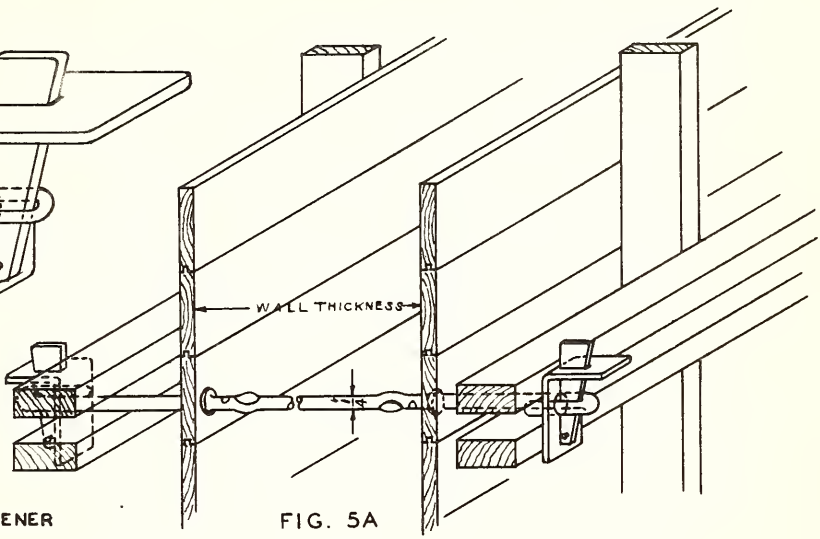


FIG. 5A

TIE ROD AND SPREADER IN FORM

adjusted from the outside of the form. Figure 5A shows a practical and popular type of rod and spreader. The wedge tightener (Fig. 5B) is used with this type of tie rod.

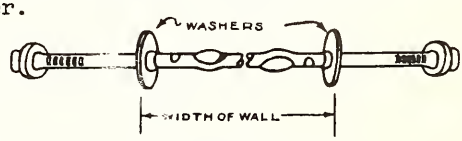


FIG. 6A

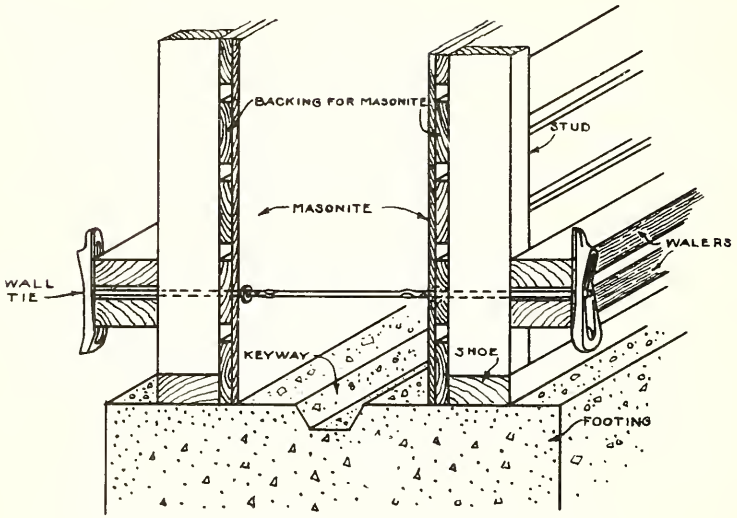
TIE ROD AND SPREADER

Another type of spreader and tie rod is shown in Fig. 6A. The tightening wedge for this rod is shown at Fig. 6B, and the complete rod in position is shown in Fig. 7.

The screw anchor type of wall tie (Fig. 8) is used by some builders for heavy work. The tie or spreader is made of heavy wire, twisted and welded at each end (B) in such a way as to form threads into which the lag screws (A) may enter. The tie rods come in different lengths for walls of different thicknesses. Holes for the lag screws are bored through the sheathing between the studs. A lag screw is then placed through the walers and into the threaded wall tie at B. The twisted ends (B), being larger than the hole through the sheathing, will not go through the sheathing. Thus, this device acts as a spreader and also as a tie.

FIG. 6B

WEDGE TIGHTENER



WOODEN FORM ON FOOTING

FIG. 7

Another type of tie rod used on heavy forms is shown in Fig. 9. A tie rod of this type may be made up on the job. This is a distinct advantage where there are many different sizes of walls. The $\frac{1}{4}$ in. rod is cut to length on the job. The rods are drawn tight by means of a tightener designed for this type of wall tie (Fig. 10). The ends are held tight by means of a cast iron button provided with a locking screw which is tightened to hold the tension drawn with tightener.

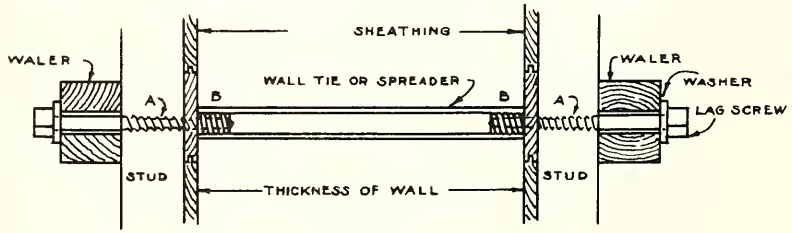


FIG. 8

SCREW TYPE TIE ROD

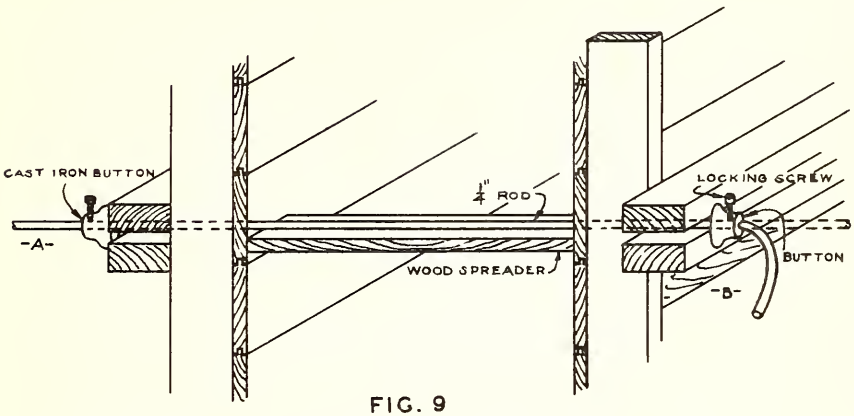
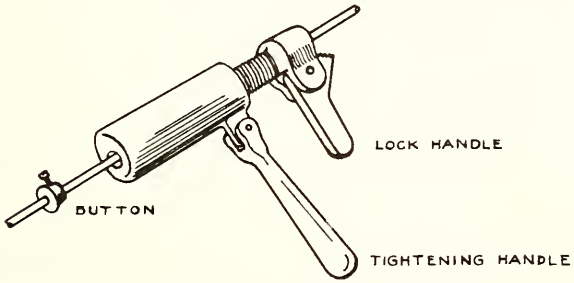


FIG. 9

BUTTON AND WRENGH TYPE TIE ROD



ROD TIGHTENING WRENCH

FIG. 10

WIRES

The twisted tie wire is the oldest method of holding forms for concrete but, due to the amount of labor required to place and tighten them, they are used only in light and shallow forms. However, there are places on forms where the manufactured type of wall tie will not work, such as in angular corners where the tie is placed at an angle to the waler. In these cases, wire, when properly placed, is the most practical method to use. In Fig. 11 a section of a form is shown with the wire in position as a tie.

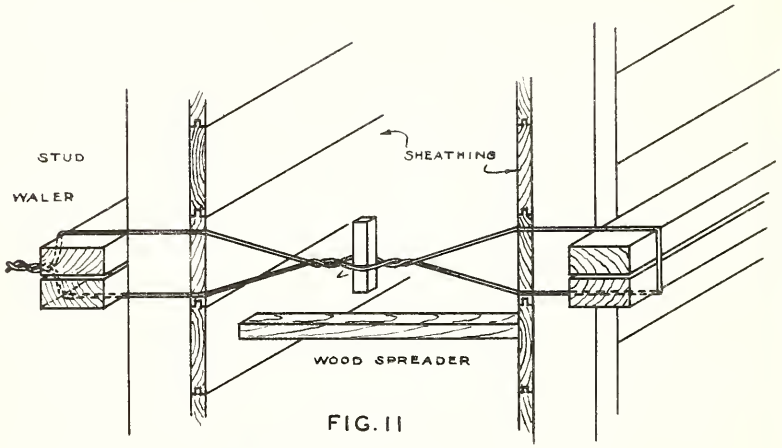


FIG. 11

TWISTED WIRE TIE

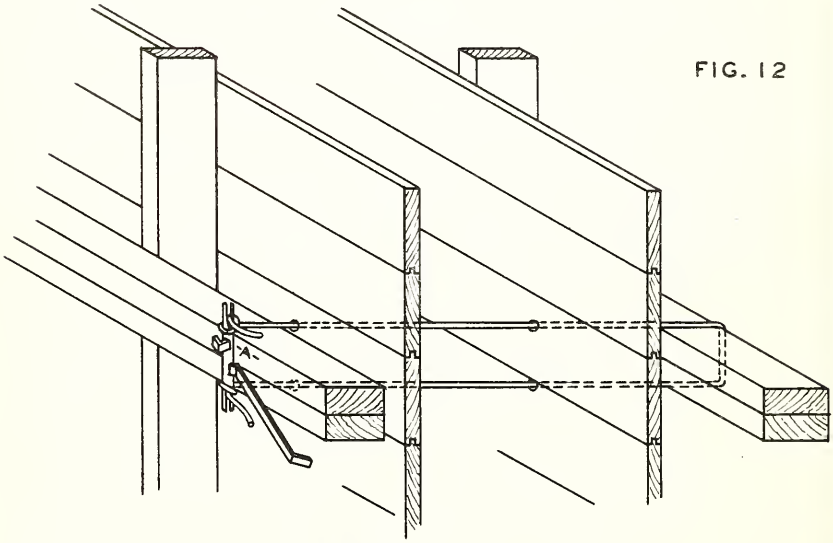


FIG. 12

WIRE CLAMP

Figure 12 shows another method of using wires as ties. The tightening is accomplished by inserting the ends of the wire into slots at each end of the tightening rod (A, Fig. 12). The rod is also provided with a slot through which a handle is placed to turn the rod, thus winding the wire until it is brought to the proper tension. The tightener is held tight by inserting a metal clip in the handle slot and against the waler.

ESTIMATING QUANTITIES OF MATERIALS FOR FORMS

Studs To find the number of studs for a form in which the stud spacing is to be 24 in. O.C. (on centers), divide the length of the form by two and add one stud for the corner. For example, a form 100 ft. long would need 51 studs (100 ÷ 2 = 50, 50 + 1 = 51). If the spacing is to be 16 in. O.C., divide by 1 1/4 instead of 2.

If 8 ft. studs are to be used, the total length of the studs would be 8 x 51 = 408 ft. To this figure, add the lengths of the plates and walers to find the total number of lineal feet of 2 x 4's required. If the walers and plates for this form are 200 ft. long, the total length of all of the 2 x 4's would be 608 ft.

Lumber is sold by board measure (B.M.). This is based on a unit 1 in. thick, 12 in. wide and 12 in. long. A piece 2 in. thick, 6 in. wide and 12 in. long would also be a board foot. A 2 x 4 which is 1 ft. long contains 8/12 or 2/3 of a board foot. In the above example, the board measure would be 608 x 2/3, or approximately 405.

Sheathing To find the amount of tongue and groove sheathing required, it is necessary to determine the number of square feet of surface to be covered. To this is added a certain percentage of this area to allow for matching and dressing. For 6 in. sheathing boards, this allowance to be added is 1/6 of the area. For example, approximately 1167 B.M. of tongue and groove sheathing would be needed to cover 1000 sq. ft. If plywood is to be used, no additions need be made to the actual area to be covered since 1000 sq. ft. of plywood will cover 1000 sq. ft. of surface.

Nails For concrete form work where the forms are not to be nailed permanently, about 15 lbs. of 8d nails are required for each 1000 B.M. of sheathing and studs.

SELECTED REFERENCES

Wood Construction ..... National Committee on Wood Utilization

Concrete on the Farm ..... The Atlas Portland Cement Co.

HOW TO USE MATERIALS IN FORM CONSTRUCTION

OBJECTIVES OF THE UNIT

1. To show how to use framing lumber for forms.
2. To show how to use sheathing for form coverings.
3. To show how to use plywood for form coverings.
4. To show how to use Masonite for form coverings.

INTRODUCTORY INFORMATION

Forms for concrete must not only be located accurately, but must also be very rigid to withstand heavy pressures. To fulfill these requirements, the carpenter must not only select the most suitable kinds of sheathing, studs, braces, ties, and other materitals, but he must also erect them in such a way that they will contribute to a strong and accurately placed form. Concrete inaccurately placed is extremely difficult to remove. Forms which bulge or break open under the pressure of the concrete cause heavy additional expense, delay, and are a source of danger to the workman.

TOOLS AND EQUIPMENT

Claw hammer	Steel tape	Steel square
Crosscut saw	Brace and bit	Wire
Carpenter's level	Common and double headed nails	Wire cutters
Chalk line	Gooseneck pinch bar	Tie rod
Bolt and washer		Hand axe

PROCEDURE

TO LOCATE WALL FORMS ON A FOOTING

1. Establish a center line along the footing as shown by the symbol ℄ in Fig. 1. A chalk line is generally used to mark this line.
2. Measure half the thickness of the proposed wall, from the center line on the footing toward the outside of the footing. This point indicates the outside of the wall or the inside of the sheathing as shown at A, Fig. 1.
3. To find the line that indicates the inside face of the shoe, add the thickness of the sheathing to half the thickness of the wall, and measure this distance from the center line of the footing, as shown at B, Fig. 1.

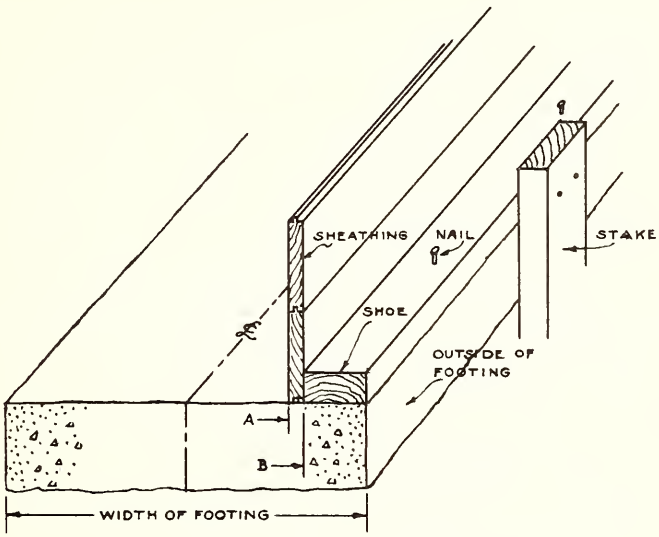


FIG. 1

LOCATING WALL FORMS ON A FOOTING

NOTE: Use the above procedure to locate the outside form on the footing. To locate the inside form, proceed in the same manner, but measure in the opposite direction from the center line.

SHOES

NOTE: Material used for shoes in form work may be either 1 in. x 6 in. or 2 in. x 4 in.

1. Select straight stock if possible.

2. Fasten the shoe to the concrete by nailing, or hold it in position by bracing it from stakes driven in the ground along the edge of the footing (Fig. 1).

HOW TO LAY OUT STUDDING

Lay out stud spacing on the shoe. Spacing may range from 12 to 24 in. on centers, depending on the thickness of the wall.

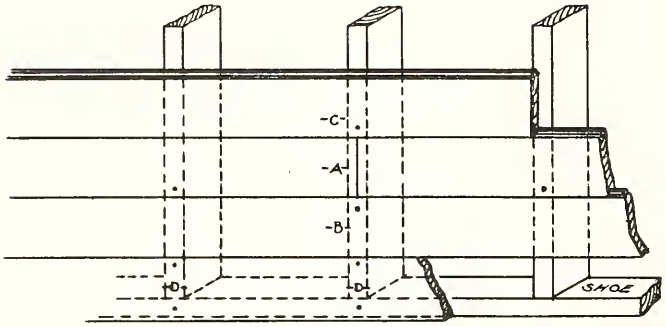


FIG. 2

FACE NAILING SHEATHING

HOW TO ERECT STUDS

1. Select studs that are free from defects and of the required length, making sure that they are straight and uniform in size.

2. Set all studs plumb and brace them temporarily. Braces should be 2 x 4 or 2 x 6 stock and should run at about a 30° angle from the horizontal.

HOW TO PLACE SHEATHING

1. Fasten the sheathing to the framework of the form with common nails. Drive the nails at an angle of 90° to the surface of the sheathing.

2. Nail the sheathing only in places where it is necessary to draw the joints tight and to secure the sheathing to the framework.

3. Nail each sheathing board at the bottom edge only, and nail each successive sheathing board at each alternate stud as shown in Fig. 2.

4. Double nail the first sheathing board laid along the top of the footing at the shoe line. See D, Fig. 2.

5. In case a joint occurs in the sheathing as at A, face nail the board B at its top edge and the board C at its bottom edge.

HOW TO PLACE PLYWOOD SHEATHING

1. Place the lower edge of all panels level, and place all joints

on studs. Plywood less than 5/8 in. in thickness should be backed up with sheathing or stringers for support between the studs. Sheathing used for backing may be laid tight or the stringers may be spaced from 2 to 4 in. apart (Fig. 7, Unit 1C-T23).

2. Nail the edges of plywood panels with flat headed nails spaced 6 to 12 in. Space the nails about 18 in. in the rest of the panel.

NOTE: One quarter inch and three eighths inch plywood requires more nails to secure it than does tongue and groove sheathing. However, it should be nailed only enough to hold it in place.

HOW TO PLACE WALERS

NOTE: Place walers along the studs of long sections of a form or where there is a tendency for the form to bulge. The walers are used to align and strengthen the form and to provide a good bearing for the top of the side braces (Fig. 3).

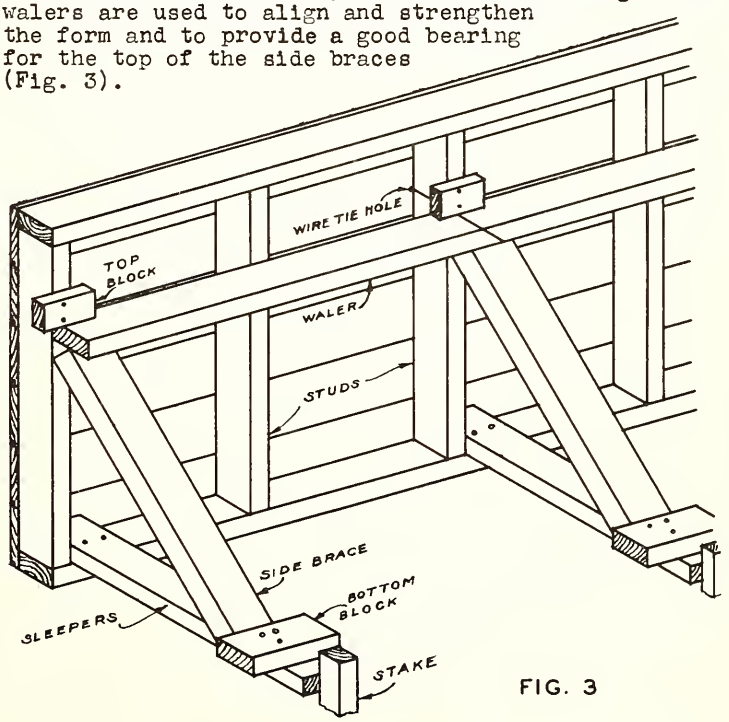


FIG. 3

BRACING A FORM SECTION

1. Place the sleepers in place and, if necessary, hold the outer end of each sleeper with a stake driven in the ground (Fig. 3).

2. Cut the braces to approximate length.

3. Place the walers at the top of the braces.

4. Nail blocks of wood on the studs at the top of the walers.

5. Plumb the form and nail a bottom block on the sleeper to hold the brace.

HOW TO USE WIRE TIES

1. Bore small holes through the sheathing at each side of the stud where the wire tie is to be placed (Fig. 3).

2. Place the wire through the holes on both sides of the form and around the walers.

3. Pull the wires tight and twist the ends together.

4. Place wood spreaders between the sides of the form and twist the wires by means of a stick until the form walls are tight against the spreaders (Fig. 11, Unit 1C-T23).

   NOTE: A wire clamp is sometimes used to pull the wires tight and to lock them in position. The wires can be tightened from the outside of the form with this device (Fig. 12, Unit 1C-T23).

HOW TO USE THE HAIR PIN TYPE OF TIE ROD

1. To use the tie rod shown in Fig. 5A, Unit 1C-T23), bore holes in the sheathing large enough to allow the eye end of the tie rod to pass through each side of the form.

2. Place the rods in the forms as each side of the form is erected.

   NOTE: When placing sheathing on the second side of the form, bore the holes and insert the tie rods before placing the walers.

3. Place the walers as shown in Fig. 5A, Unit 1C-T23, so that the tie rod may enter between them.

4. Insert the wedge into the loop end of the rod and drive the wedge down until the spreader washers are tight against the inside of the sheathing.

HOW TO USE THE LAG SCREW TYPE OF TIE ROD

NOTE: Place the lag screw type of spreader (Fig. 8, Unit 1C-T23) in the form after one side has been sheathed and the walers have been put in place.

1. Bore a hole in the sheathing and waler 1/16 in. larger than the lag screw.

2. Place the lag screw and a large washer in position thru the waler. Turn the wall tie on the lag screw.

3. Tie up the opposite side in the same manner after the sheathing and walers have been placed.

4. Tighten the lag screws with a wrench until the spreader is drawn tightly against the form siding.

NOTE: Keep the lag screw holes on opposite sides of the form at the same height; also keep the spreader at a right angle to the inside of the form.

HOW TO USE THE BUTTON TYPE ROD

1. Bore holes through both sides of the sheathing large enough to admit the rod, as shown in Fig. 9, Unit 1C-T23 .

2. Place the button on one end of the rod and tighten the set screw as shown at A, Fig. 9, Unit 1C-T23.

3. Slide the rod through the form until the tightened button is against the waler on one side.

4. Slide a button on the opposite end of the rod and place the tightening wrench (Fig. 10, Unit 1C-T23) on the rod behind and close to the locking button (B, Fig. 9, Unit 1C-T23).

5. Place a wood spreader between the forms and opposite the studs.

6. Hold the locking handle of the tightening wrench in the left hand and turn the tightening handle clockwise with the right hand. This will expand the wrench and draw the two buttons tight, thus pulling the two sides of the form against the spreader.

7. Tighten the set screw on the button at B, Fig. 9, Unit 1C-T23 and remove the wrench.

8. Bend down the end of the rod extending outside the locking button, because these ragged ends are dangerous to the workman.

DESCRIPTION OF ANCHOR BOLTS IN FORM CONSTRUCTION

OBJECTIVES OF THE UNIT

1. To describe types of anchor bolts.

2. To point out the need for anchor bolts.

INTRODUCTORY INFORMATION

An anchor used in building construction is a rod, metal strap, or bolt which secures wood framework to masonry. One end of the metal anchor must be firmly embedded in the solid masonry wall and the other end must be fastened firmly to the sill.

NEED FOR ANCHOR BOLTS

Buildings are anchored to masonry walls to prevent them from shifting from the wall. When a building moves off a wall, there are two distinct movements. First, the building will be lifted vertically and then moved laterally or sideways. This upward movement is caused by the wind getting under the covered roof or sub-floors of a building under construction. This is particularly likely to happen in a building with the platform type of framing in which the sub-floors are laid as the framework is erected to the attic floor line, and the openings in the side walls are not covered. This allows the wind to get under the floors and lift the building.

Carpenters should take these things into consideration in the construction of the framework of army barracks by mass production methods. The buildings are set upon piers extending about two feet above the ground, and although they are anchored to the piers, it will not take a very high wind to move the building off the piers, once the wind gets under the floors or roof. This same danger also exists in family dwellings, particularly where the building is two full stories in height. Anchor bolts or straps connecting the building to the piers or foundation walls should be provided but they will be put under a heavy stress if a strong wind gets under the superstructure of the building.

In mass erection of buildings, it is a common practice to frame and roof as many of the buildings as possible while the weather is good. In bad weather or on rainy days, the carpenters work on the inside of the buildings to finish the partitions, set window frames, and finish as much of the inside work as possible. If this procedure of construction is followed, the skirting should be applied and the window openings of the sheathed side walls should be enclosed on the windward side of the buildings as soon as possible. In no case should the roof be covered before the side walls are enclosed.

SOME COMMON TYPES OF ANCHOR BOLTS

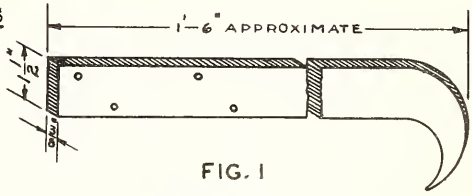


FIG. 1

FLAT BAR ANCHOR

Military barracks are often built on a group of piers, and the beams are of the built-up type. The anchors in this type of building usually consist of flat bars drilled at one end to allow them to be spiked to the beam. The other end is formed into a hook or key which is embedded in the masonry pier (Fig. 1).

The anchor most commonly used in homes and garages is a threaded rod with a nut and washer on one end. The other end is bent to hold in the concrete (Fig. 2).

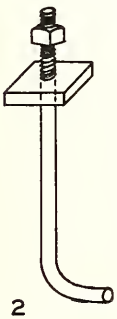


FIG. 2

BENT ROD ANCHOR

Figure 3 shows a straight bolt with nuts and washers and with a piece of pipe placed around the bolt. This prevents the concrete from forming tightly around the bolt, thus allowing it to swivel. This makes fitting sills or equipment bases to the anchor bolts much easier than if the bolts were embedded solidly in concrete.

A combination anchor and bearing plate used to anchor steel beams to piers is shown in Fig. 4. The angle clips are bolted or riveted to the steel column, and have holes which coincide with holes in the bearing plate. The rods that are to be embedded in the concrete protrude through the holes in the angle clip and plate and are fastened with a nut as shown.

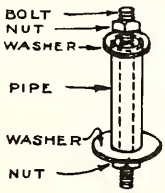


FIG. 3

FLEXIBLE ANCHOR

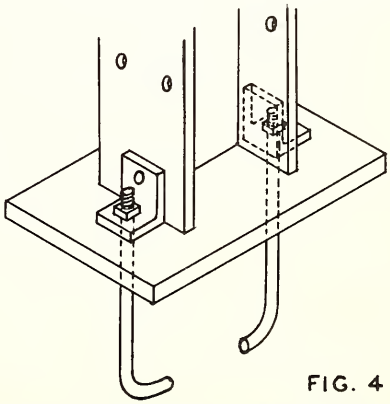


FIG. 4

COMBINATION ANCHOR AND BEARING PLATE

HOW TO SUSPEND ANCHOR BOLTS

OBJECTIVES OF THE UNIT

1. To show how to install anchor bolts in forms.

INTRODUCTORY INFORMATION

Anchor bolts which are to hold plates, sills, girders, structural steel, or machinery must be set accurately in the concrete so they will enter the holes in these members. The bolts must also be located accurately in the form and must be kept in place by the use of a wooden templet or pattern in which holes are bored at the proper points to receive the bolts. The templets should be securely fastened to the top of the form.

TOOLS AND EQUIPMENT

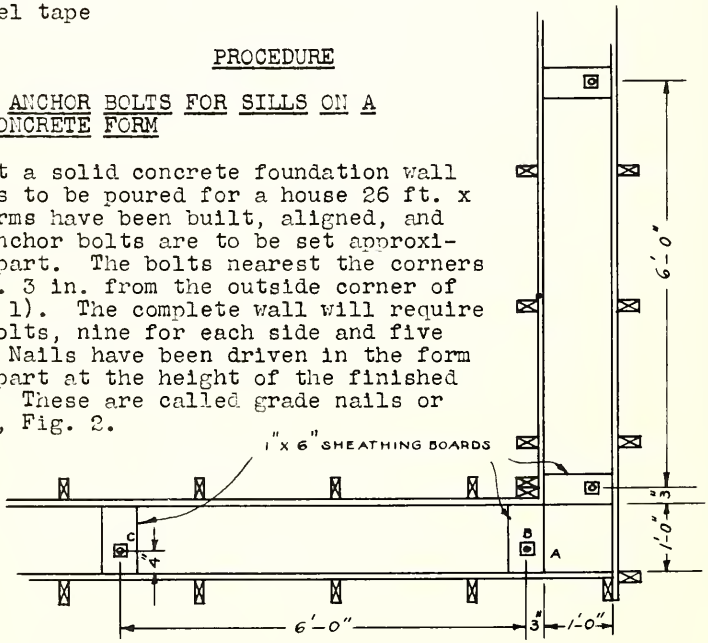
Rule
Brace and bit
Steel square
50 ft. steel tape
Wrench
Hammer
Crosscut saw

PROCEDURE

HOW TO INSTALL ANCHOR BOLTS FOR SILLS ON A CONCRETE FORM

Assume that a solid concrete foundation wall 12 in. thick is to be poured for a house 26 ft. x 50 ft. The forms have been built, aligned, and braced. The anchor bolts are to be set approximately 6 ft. apart. The bolts nearest the corners are to be 1 ft. 3 in. from the outside corner of the wall (Fig. 1). The complete wall will require twenty-eight bolts, nine for each side and five for each end. Nails have been driven in the form about 10 ft. apart at the height of the finished concrete wall. These are called grade nails or points. See A, Fig. 2.

FIG. 1



LAYOUT OF ANCHOR BOLTS IN FORM

1. Snap a chalk line from one grade nail to the next, making a continuous line around the form (B, Fig. 2).

2. Cut 28 pieces of sheathing 1 in. x 6 in. x 12 in. These are to be placed in the form to suspend the anchor bolts until the concrete has set.

3. Nail the first piece in place with its center line 1 ft. 3 in. from the outside corner of the wall, See Fig. 1 at A. The under side of the piece should be at the same height as the chalk line (B, Fig. 2).

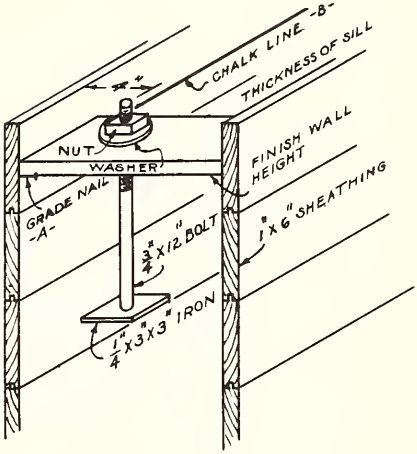


FIG. 2

DETAIL OF SUSPENDED ANCHOR BOLT

4. Locate the first anchor bolt hole by measuring in 4 in. from the outside face of the wall along the center line of the piece of sheathing. Drive nail temporarily at this point (Fig. 1 at B).

5. Hook the ring of a steel tape over the nail. Run the tape out and mark the form every 6 ft.; that is, mark at 6 ft., 12 ft. and 18 ft. These points mark the center lines of the 12 in. boards.

6. Locate and fasten the boards at these points in the manner described in Step 3.

7. Locate the hole in each board as described in Step 4.

8. Bore holes at these points, 1/16 in. larger than the anchor bolt that is to be used.

9. Slip the bolts in place and run the nut and washer down on the bolt until it projects above the concrete line the thickness of the sill plus about 1/2 in.

NOTE: When the concrete is being poured, be sure that it does not push the bolts out of place.

HOW TO INSTALL ANCHOR BOLTS FOR ENGINE BEDS AND STEEL COLUMNS

NOTE: Figure 3 shows a method of using a wooden templet to suspend a group of anchor bolts where accuracy is important. An example of this would be in setting anchors for an

engine bed or for steel columns. If the templet is made as a complete unit and installed on the form as such, it should be squared and nailed together first, so it will remain square until secured in position.

NOTE: Figure 4 shows anchor bolts with small pipes around the bolts as described in Unit 1C-T24.

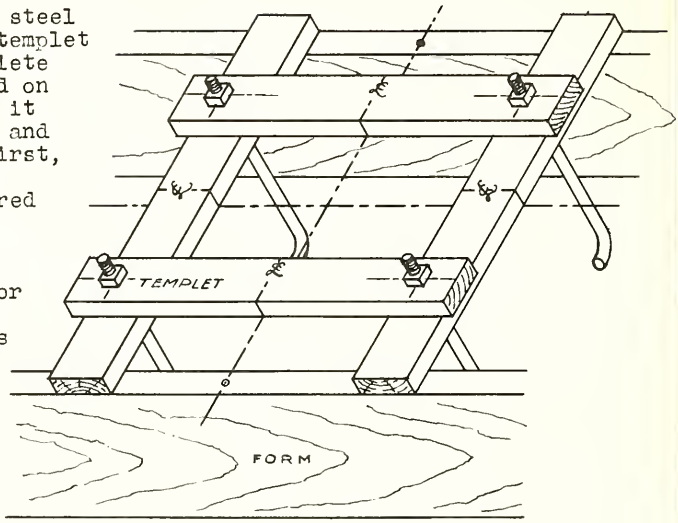


FIG. 3

ANCHOR BOLTS HELD IN POSITION BY TEMPLET

1. To locate these anchors, proceed as in locating anchors for columns and engine beds.

NOTE: The washer to be embedded in the concrete should have a diameter of at least 2 in. greater than that of the pipe used around the bolt.

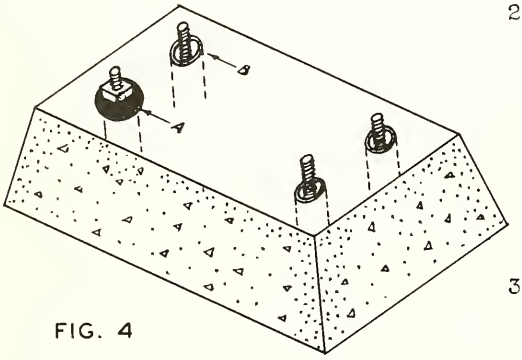


FIG. 4

FLEXIBLE ANCHOR BOLTS IN PLACE

2. Place a washer of approximately the same size as the outside diameter of the pipe, on the upper end of the bolt and draw it down tightly against the pipe with the nut. This prevents the wet concrete from getting into the inside of the pipe (A, Fig. 4).

3. Suspend the bolts in the templet so that the top edge of the pipe will be level with the top of the finished concrete work (B, Fig. 4).

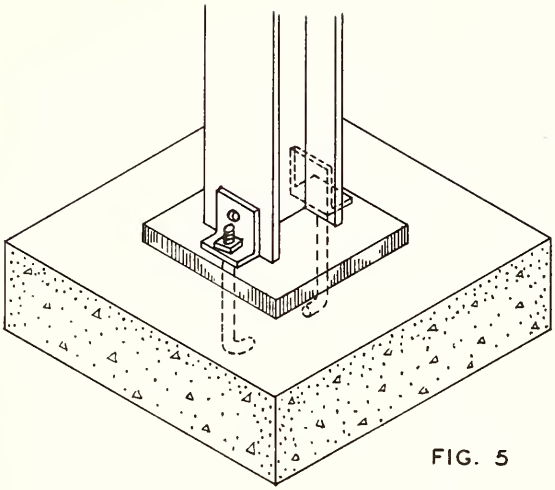


FIG. 5

ANCHOR AND BEARING PLATE IN POSITION

NOTE: Figure 5 shows a combination anchor bolt and bearing plate. These plates come in many different styles, some being welded together and some bolted. However, the procedure in locating them in the concrete is similar to that used for the other type described.

DESCRIPTION OF FORMS FOR CONCRETE PIERS AND WALL FOOTINGS

OBJECTIVES OF THE UNIT

1. To describe footings for piers and walls.

2. To describe forms for piers and columns.

INTRODUCTORY INFORMATION

A pier is a post or column extending into and above the ground and supporting a structural member of a building. It may be made of wood, metal, or concrete, the size and shape being governed by the weight of the structure it is to support.

Footings for piers and walls are made in many different ways, the size, design and construction depending on the load to be carried and the bearing strength of the soil. The fundamental purpose of a footing is to distribute the load imposed on the pier over a larger area of ground than would be covered by the pier or column itself.

FACTORS TO BE CONSIDERED IN FOOTING CONSTRUCTION

A footing should be made strong enough to support the dead weight of the wall or pier and also the live and dead weight imposed on the wall. In general, a footing for a foundation wall or pier for light frame construction should extend no more than 4 in. beyond each side of the wall or pier, unless the footing is reinforced or tapered.

The thickness of the footing should be 10 in. to 12 in. If keyways are used, they should not impair the strength of the footing. That portion of footings and piers which is above the frost line should be tapered slightly toward the top so that the heaving of the soil will not tend to heave the pier.

Once frost gets under footings it will raise them. This is particularly true of small light buildings such as garages and houses. It is doubtful whether frost could raise a masonry building which is two or three stories high. Nevertheless, the footings of such buildings are placed below the frost line.

If the building site slopes, and if the excavation is dug parallel to this slope and the footings

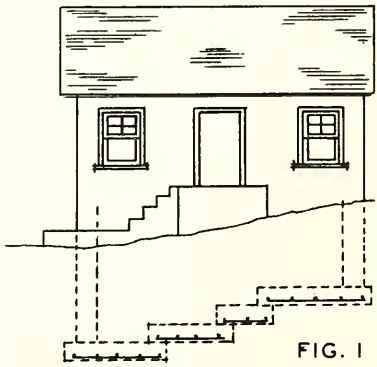


FIG. 1

STEPPED FOOTING

are poured accordingly, there will be a tendency for the building to "creep" or slide to the lowest point. This may be overcome by stepping the excavation to meet the contour of the ground. The thickness of one footing that laps over another should not be less than 8 in. See Fig. 1.

TYPES OF FOOTINGS

Footings may be classified into two general groups; pier or independent footings, and wall or continuous footings.

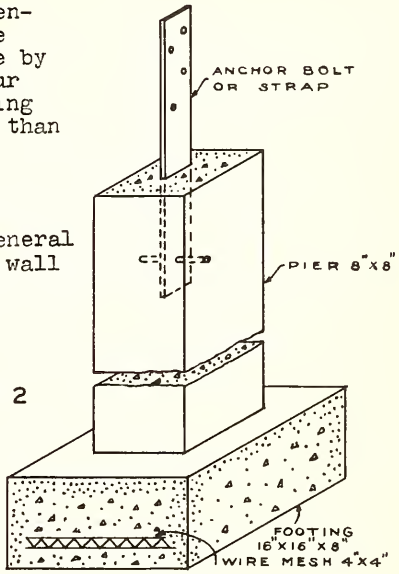


FIG. 2

PIER AND FOOTING FORM

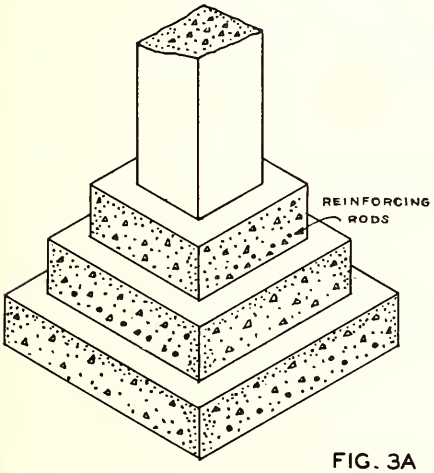


FIG. 3A

STEPPED FOOTING

PIER FOOTINGS

Pier or column footings may have stepped or tapered sides. Figure 2 shows the type of pier used in military barracks and for ordinary garage and light frame construction.

Figure 3A shows the stepped footing generally used where the load on the pier per square foot is greater than the bearing strength of the

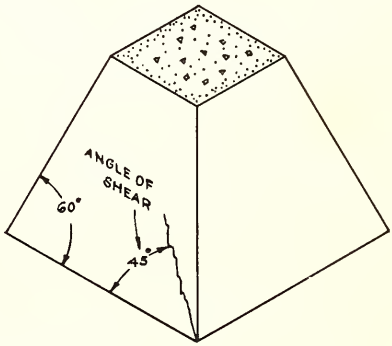


FIG. 3B

TAPERED FOOTING

soil per square foot. Figure 3B shows the tapered footing which is also used to distribute the load over a large area. The sides are tapered to conserve material and to prevent frost from heaving the footing.

The angle of slope used for this type of pier footing should be 60° from the horizontal. This is based on the fact that the angle of shear caused by a load on the footing is 45°. This angle is well within the limits of the 60° sloped sides of the pier footing. See Fig. 3B.

Combination wall and column footings are used when a wall and a column are combined to form a pilaster (Fig. 4). This type of footing is used where piers are set at intermediate points in a continuous wall such as at A, Fig. 4, or where there is a concentrated load on the wall.

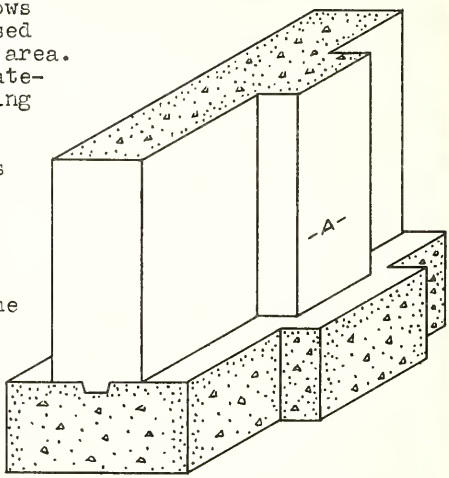


FIG. 4

PILASTER WALL FOOTING

CONTINUOUS WALL FOOTINGS

Footings are generally shown on foundation plans by dotted lines on both sides of the wall (Fig. 5). These lines represent the outside and inside edges of the footings. The section through the wall at A-A

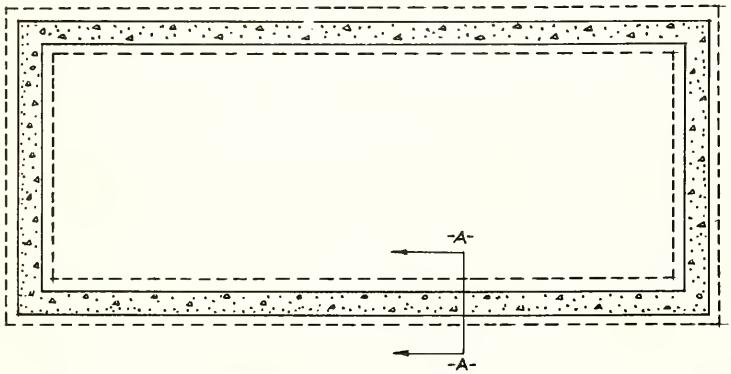
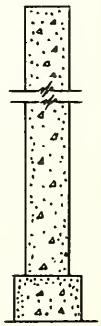


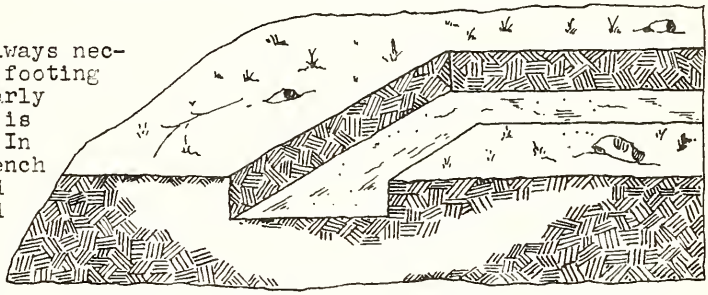
FIG. 5 - FOOTING LINES ON FOUNDATION PLAN



SECTION A-A

shows the size of the footing. In this case the wall is one foot thick with a 4 in. projection on each side of the wall, making the footing 1 ft. 8 in. wide. The thickness or depth of the footing is 1 ft.

It is not always necessary to build footing forms, particularly where the earth is solid or firm. In this case, a trench may be excavated to the width and depth of the footing and concrete poured into this trench (Fig. 6). This saves considerable time and material, but if the soil is such that it will not stand up firmly and is porous it will be necessary to build forms.



TRENCH TO ACT AS FORM FOR CONCRETE FOOTING

FIG. 6

FOOTING FORMS

Concrete footing forms (Fig. 7) are usually constructed of 2 in. planks set on edge. The width of the plank is the same as the depth of the footing. These planks are held in place with stakes and are held the correct distance apart with cross-spreaders or ties. At each stake, a short brace holds the forms in line. Due to irregularities in the excavation, it may be necessary to trim off dirt in some places to get the footing form level. In other places, the form may have to be raised. Dirt is then thrown around the outside of the form to prevent the wet concrete from running out. The concrete is then poured into the forms and screeded off level with the top of the planks.

Another type of form is used where it is impossible to drive stakes to hold the forms in place. This will occur where the foundation is hardpan or rock. In this case, the planks used are wider than the depth or thickness of the footing. The top of the forms are not set to any definite level, but are set to meet the contour of the ground.

The form is made by fastening 2 x 4 cleats to the sides of the planks and building the form sides higher where necessary to follow the contour of the ground. See A, Fig. 8. Short braces are placed against each cleat, or dirt may be piled at each cleat to hold the form in place. The planks are held in place with a tie at the top and one directly below. In some cases, it is not possible to have

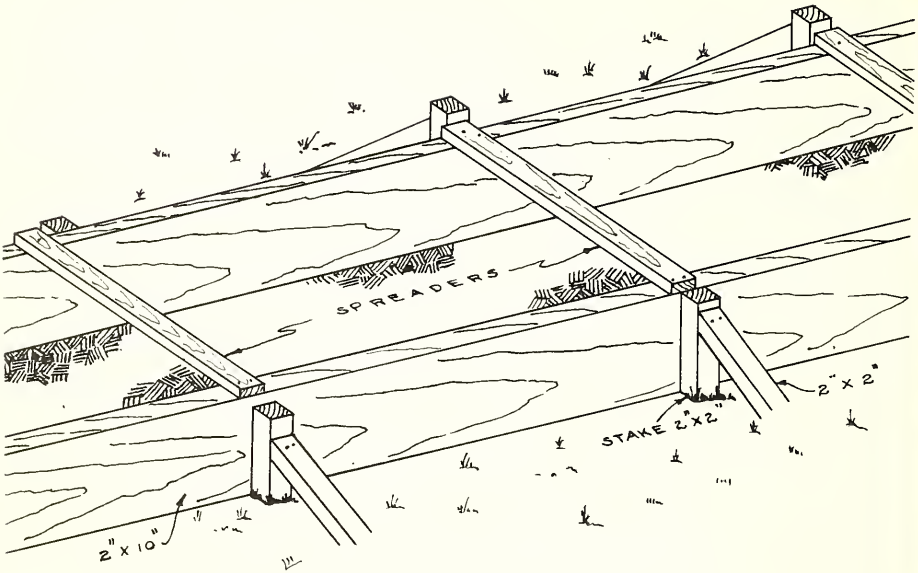


FIG. 7

FOOTING FORM

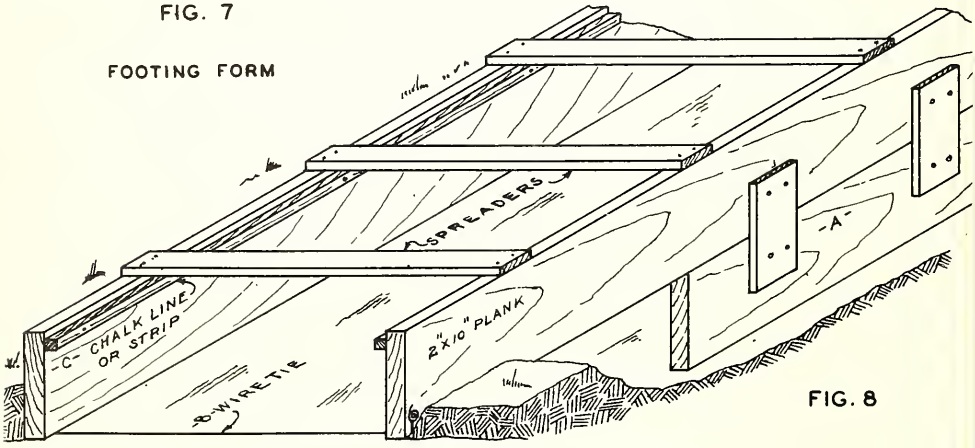
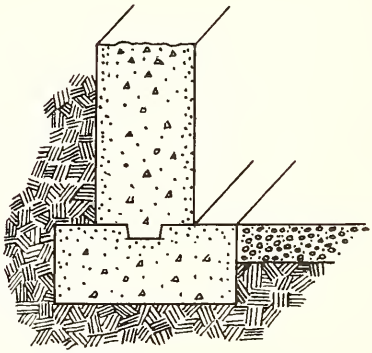


FIG. 8

FOOTING FORM FOR HARD IRREGULAR GROUND

wood spreaders at the bottom of the form. In this case, wires may be used instead of wood (B, Fig. 8). Because of the difficulty of making the forms level, they are made higher than necessary, and grade nails or strips are placed on the inner sides of the form at the elevation of the top of the footing. Concrete is then poured and screeded off at the strip or nails. This method is the quickest and easiest for the carpenter but causes some difficulty for the concrete gang (C, Fig. 8).



FOOTING BONDED TO WALL

FIG. 9

BONDING A WALL TO A FOOTING

Some provision is necessary for tying the wall above to the footing below, particularly where one side acts as a retaining wall (Fig. 9). If no such provision is made, there will be a tendency for the wall to be pushed off the footing due to the pressure of the earth on one side with nothing on the other side to counteract it. A keyway in the center of the footing will prevent this. The keyway may be made either by pressing a slightly beveled 2 x 4 into the concrete while it is still wet and then removing it when the concrete has set (Fig. 10A), or by pressing hard bricks into the footing and allowing about one half to project above the top of the footing (Fig. 10B). Iron dowels or reinforcing rods may also be used to fasten a wall to a footing. In a case where the footing and the wall can be poured together, the keyway or rods are not necessary.

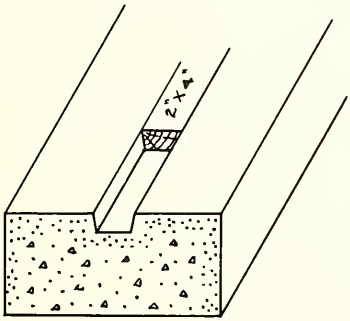


FIG. 10A

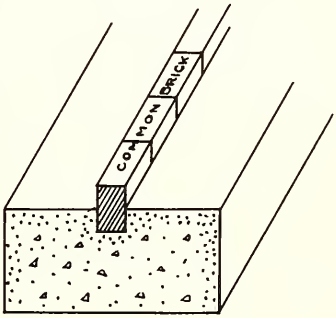


FIG. 10B

METHOD OF MAKING KEYWAY

Forms for concrete piers are made of several types of materials. The most common type of form is made of tongue and groove sheathing, nailed together with cleats to form a rigid panel for a side of the pier form (A, Fig. 11). Four sides are made in this manner, the width and length being dependent on the size of the concrete pier to be constructed. These four sides are then nailed together in the form of a square and are held together by yokes or column clamps shown at

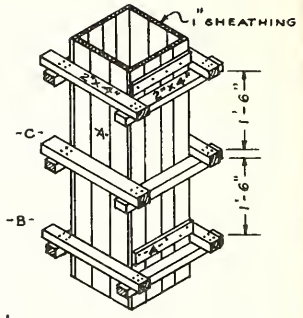


FIG. 11

FORM FOR SHORT COLUMN

B and C, Fig. 11. These yokes prevent the wooden form from bulging when the concrete is poured, and hold the form in shape until the wet concrete has set. This type of form is used for columns or piers less than 5 ft. high and not over 2 ft. square. Where footings are required underneath the pier, box-like frames of the size of the footing are made.

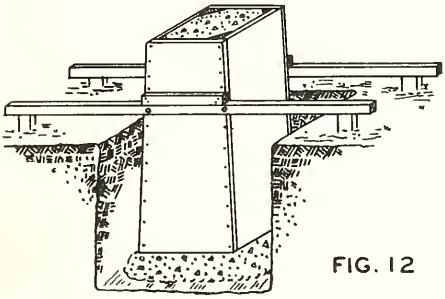


FIG. 12

FORM FOR TALL COLUMN

A form that is sometimes used is shown in Fig. 12. It measures 10 in. to 12 in. each way on the top and is somewhat larger at the bottom so it can be lifted off the concrete. The top level of the pier can be regulated by putting blocks under the handles of the form. By digging the hole for the base of the pier about 6 to 8 in. larger each way than the form, provision may be made for forming the footing of the pier.

Column and post forms that are filled with concrete in an upright position are subjected to greater pressure near the bottom of the form, therefore, they must be built more strongly at the bottom than at the top. The easiest way to do this is to put the yokes or

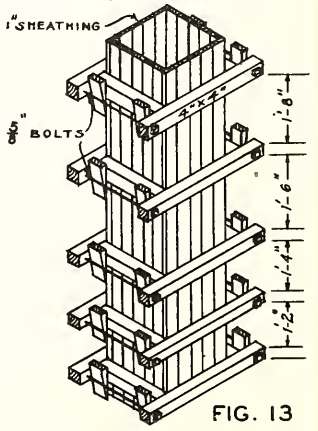


FIG. 13

REMOVABLE PIER FORM

clamps more closely together near the bottom of the form. In column forms, the boards should be placed vertically and should be tongued and grooved so the pressure of the concrete will not force water and cement between the boards (Fig. 13).

Large, heavy columns must have stronger forms because of the great weight of the concrete at the bottom (Fig. 13). These forms have yokes of 4 x 4 material held together by bolts, and side pieces held in position by wedges.

The forms may be taken off a concrete column that is to carry no weight, within 24 to 48 hours after the concrete has been poured into the form. Forms for load bearing piers should be left on 48 to 96 hours.

SELECTED REFERENCES

Concrete on the Farm ..... The Atlas Portland Cement Co.

A Vocational Course in Concrete ..... Portland Cement Association

Alpha Cement - How to Use It ..... Alpha Portland Cement Co.

HOW TO CONSTRUCT AND SET FORMS FOR PIERS AND FOOTINGS

OBJECTIVES OF THE UNIT

1. To show how to construct forms for piers and footings.
2. To show how to construct forms for piers.
3. To show how to set forms for pier footings.
4. To show how to construct and set forms for wall footings.

INTRODUCTORY INFORMATION

In some cases, the footing forms and the pier or wall forms are each set and poured separately. In this type of construction, the two masses of concrete must be bonded together. Another method of building this footing and pier is to construct the form in such a manner that the footing and pier can be poured together. Either of two methods might be used to accomplish this. Separate forms may be built and set together, or only the pier form may be used and the footing formed by the enlargement of the bottom of the excavation.

TOOLS AND EQUIPMENT

Rip saw	Steel square	Pliers
Crosscut saw	Chalk line	Rule
Portable electric saw	Brace	Wire
Hammer	Steel tape	Plumb bob
Spirit level	Auger bit	

PROCEDURE

HOW TO MAKE A SMALL PIER FORM

NOTE: Figure 12 in Unit 1C-T25 shows a method of forming a simple pier that may be used for light frame buildings.

1. To make this form, cut the four sides to the desired width from solid wide boards and taper them as shown. Apply grease to the inside of each panel.
2. Nail the sides together and fasten the handles in place.

NOTE: If plywood is used it will be necessary to reinforce the corners with cleats and nails as nails alone will not hold them securely enough.

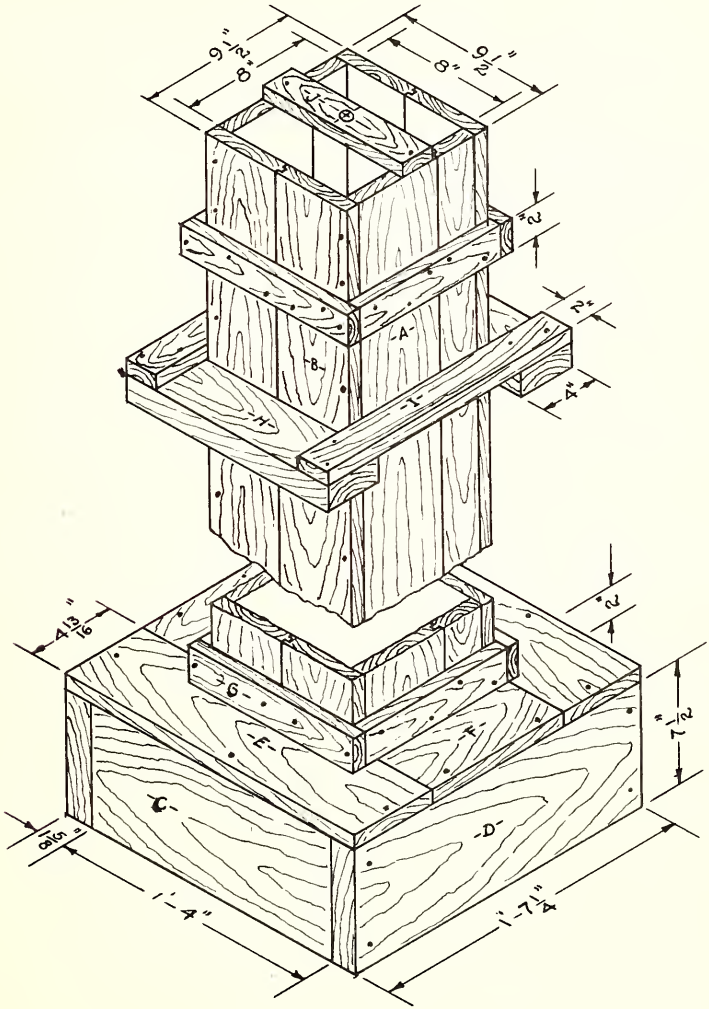


FIG. 1

PIER AND FOOTING FORM

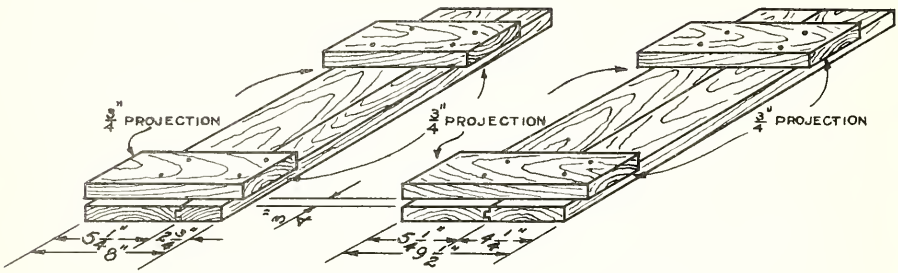


FIG. 2A FIG. 2B

PIER FORM SIDES

HOW TO MAKE A COMBINATION FCOTING AND PIER FORM

1. Rip a piece of sheathing of the required length to 2 3/4 in. wide. Match this piece with a 5 1/4 in. wide sheathing board and fasten them together with cleats as shown in Fig. 2A. Allow the ends of the cleats to project 3/4 in. Make another panel of the same size. One of these panels is shown at A, Fig. 1. The other on is on the opposite side of the form.

2. Rip two pieces of sheathing 4 1/4 in. wide and match each piece with a 5 1/4 in. wide sheathing board. Build two panels as described in Step 1 and as shown in Fig. 2B. These are to be used as shown at B, Fig. 1.

3. To assemble the four panels, butt them together and nail as shown in Fig. 1.

4. Make a framework for the footing by cutting two pieces of 1 5/8 in. x 7 1/2 in. as at C, Fig. 1, and two pieces as at D. Nail these pieces together as shown.

5. Square the frame and fasten pieces of sheathing on two sides of the frame as shown at E. Cut two pieces and fasten them as shown at F.

6. Insert the pier form into the hole left in the top of the footing form. The pier form will be supported on the footing form by the cleats (G).

7. Make yokes as shown at H and I and place one such yoke every two feet on the pier form.

8. If anchor bolts are to be used, fasten a templet (J) to the top of the form as described in Unit 1C-P24.

HOW TO MAKE AN INDIVIDUAL PIER FOOTING FORM

1. Figure 3A shows a form made of 1 in. stock. To make the sides A and B, cut six pieces to the required width and length to correspond to the thickness and length of the concrete footing.

2. To make the sides C and D cut six pieces the same width as those of sides A and B but 8 in. longer. This extra length is the allowance for the width of the cleat (E) and the thickness of the sheathing of sides A and B.

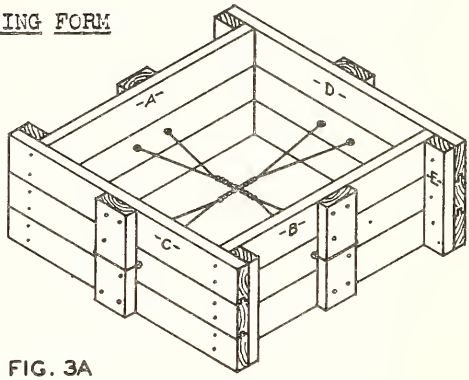


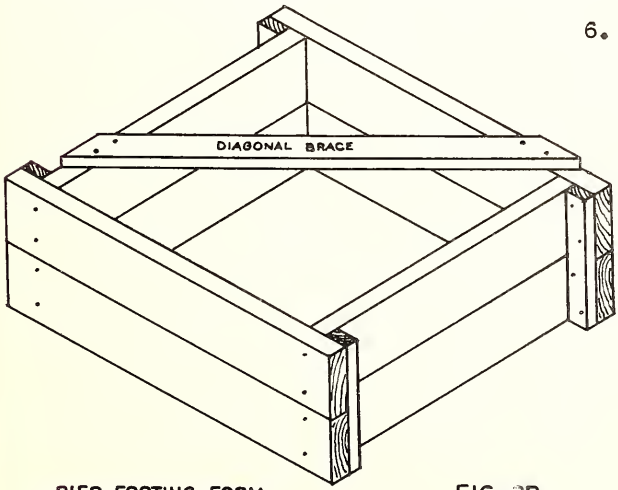
FIG. 3A

PIER FOOTING FORM

3. Nail the cleats on the outside of the form as shown, and square the form.

4. Place a diagonal brace as shown in Fig. 3B.

5. Bore holes and insert wires in sides C and D first. Twist the wires tight, drawing the sides C and D firmly against the sides A and B.



PIER FOOTING FORM

FIG. 3B

6. Insert wires in sides A and B and twist them lightly so as not to pull the sides away from the cleats E.

NOTE: Figure 3B shows a similar form made with 2 in. stock. This type of form requires no wires or cleats because the heavy stock is rigid and provides better nailing.

HOW TO MAKE A STEPPED FOOTING FORM

NOTE: The stepped form is a series of individual forms made to the required size of the footing. The individual parts are made similar to the form shown in Fig. 3B. The complete form is shown in Fig. 4A.

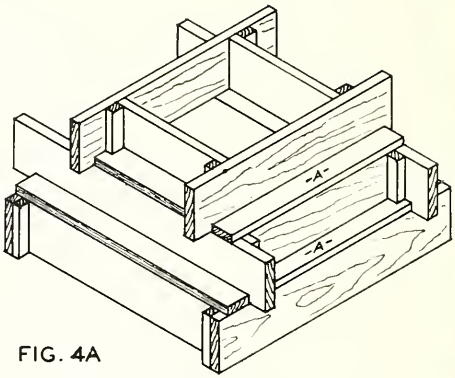


FIG. 4A

STEPPED FOOTING FORMS

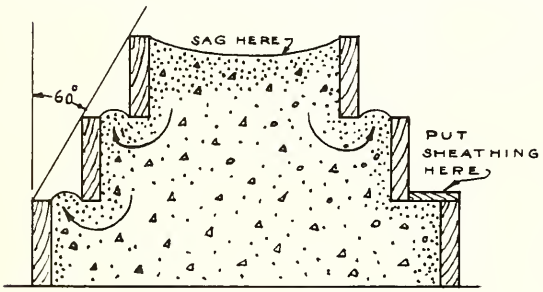
1. Place sheathing boards over the openings at the top of each step of the form as at A, Fig. 4A.

NOTE: Figure 4B shows a section of the stepped form with one top sheathing board in place. If these boards are not provided, the resulting shape of the concrete pier will be as shown.

HOW TO MAKE TAPERED FOOTING

NOTE: To make the sides A and B, Fig. 5A, proceed in the manner described for making the sides of the form in Fig. 3A except that allowance must be made for the taper of the sides.

1. Match the required number of sheathing boards together, and lay off the width of the bottom of the pier on board A, Fig. 5B. Lay off the width of the top of the pier on board B. Be sure to work from a center line.



SECTION OF STEPPED FORM

FIG. 4B

2. Mark off straight lines connecting the bottom and top points.

3. Cut along these lines and nail the cleat in place as shown in Fig. 5B. Make two of these panels.

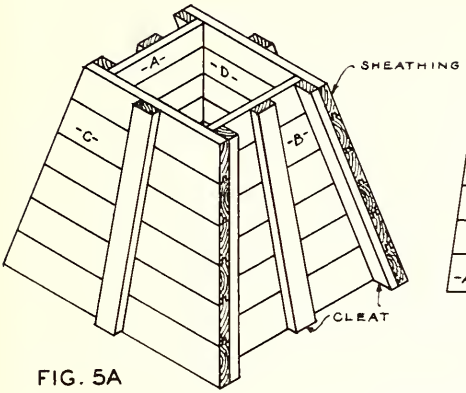


FIG. 5A

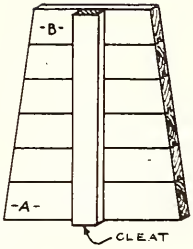


FIG. 5B

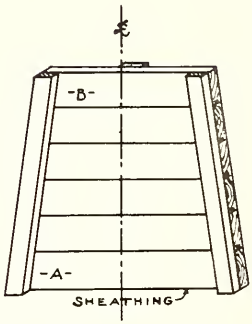


FIG. 5C

BATTERED PIER FORM

4. To make the sides C and D, Fig. 5A, follow the same procedure, making allowances so these sides will fit against sides A and B. Nail the three cleats as shown in Fig. 5C.

5. Assemble and brace the form as shown in Figs. 3A and 3B.

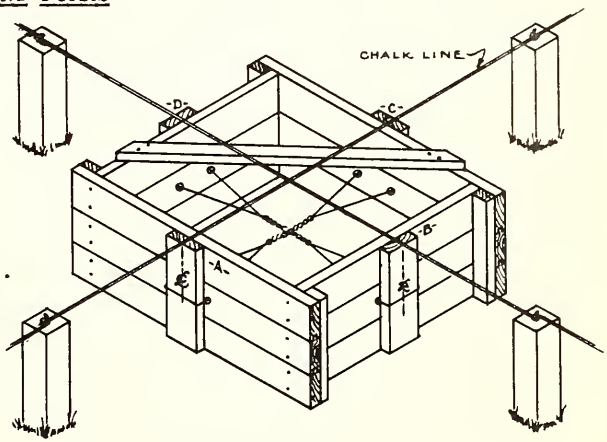
HOW TO SET AND BRACE FOOTING FORMS

1. Locate the two center lines of the proposed pier footing by stretching chalk lines on stakes as shown in Fig. 6.

2. Mark the center of the top of each side (A,B,C,D, Fig. 6).

3. Place the form directly below the chalk lines so each center mark (A,B,C,D) lies directly under the chalk lines.

4. Level the footing form and check its location as to center lines.

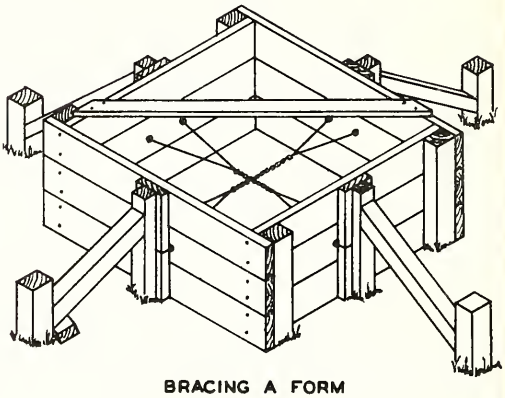


SETTING PIER FORM BY CENTER LINES

FIG. 6

5. Brace the form as shown in Fig. 7 or pack earth around it as shown in Fig. 8.

6. Locate and brace pier forms, such as shown in Fig. 1, in a similar manner, but place additional braces against the column yokes (H) and extend them to stakes driven into the ground.



BRACING A FORM

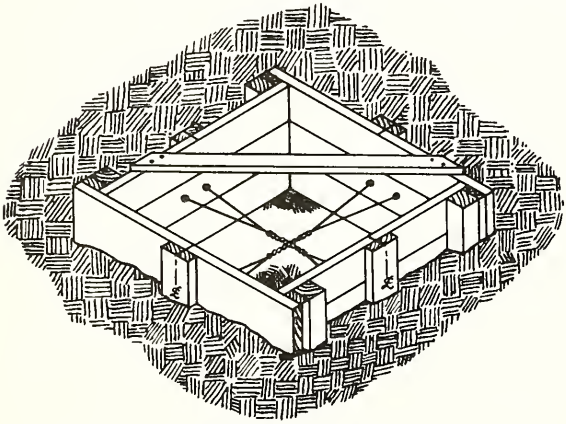
FIG. 7

HOW TO BRACE STEPPED OR TAPERED FOOTING FORMS

1. To brace this type of form, use side bracing similar to that used for the other footing forms.

2. To brace the form against heaving or floating by the method shown in Fig. 9A, cut the upright and crosspiece to length as shown, and toe nail the upright to a floor beam and to the crosspiece. Then nail the crosspiece to the top of the form.

3. To brace the form against heaving or floating by the method shown in Fig. 9B, nail planks along two sides of the form. Nail two cross planks on top of these, forming a platform on which heavy weights may be placed.



FORM SET IN GROUND

FIG. 8

4. Figure 9C shows another method of anchoring a tapered form. Partly fill the form with concrete. Place a wire anchor in the concrete and after the concrete has hardened, twist the wire around the crosspiece at the top of the form.

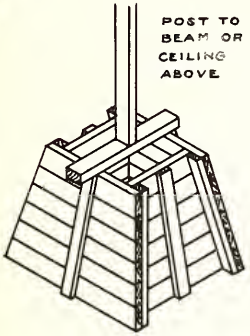


FIG. 9A

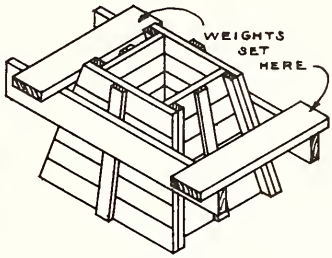


FIG. 9B

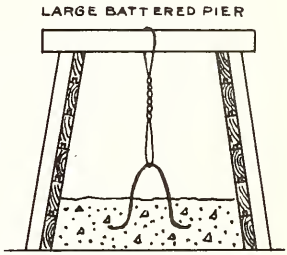


FIG. 9C

METHODS OF ANCHORING PIER FORMS

HOW TO MAKE AND SET FORMS FOR WALL FOOTINGS

1. To set the footing forms in the proper relation to the building lines, place chalk lines on the batter boards as they were during the layout of the excavation.

2. At the corners of the building line, shown by the crossing of the chalk lines (A, Fig. 2, Unit 1C-P21), plumb down into the excavation to locate the outside corner of the wall. Measure from this point to locate the stakes (B and C, Fig. 10), marking the outside and the inside corners of the footing, allowing for the thickness of the form material and the projection of the footing beyond the face of the wall.

3. Drive the top of each stake (B and C) down to the level of the top of the proposed footing.

4. Repeat this operation at each corner of the excavation. Drive a nail in the top of each stake.

5. Stretch chalk lines from these nails, to show the alignment of the inside and outside footing forms (Fig. 10).

6. Make the side walls of the footing forms, using 2 in. planks of the same width as the thickness of the footing.

7. Nail 2 in. strips across the top of the form about every 3 ft. Drive stakes into the ground against the outside of the form to keep the bottom of the form from spreading.

8. Drive stakes (D, Fig. 10) firmly into the ground about 12 in. from the sides of the form and insert the braces.

NOTE: After the forms have been braced and earth has been packed around the outside of them, they should be rechecked as to levelness and correct alignment.

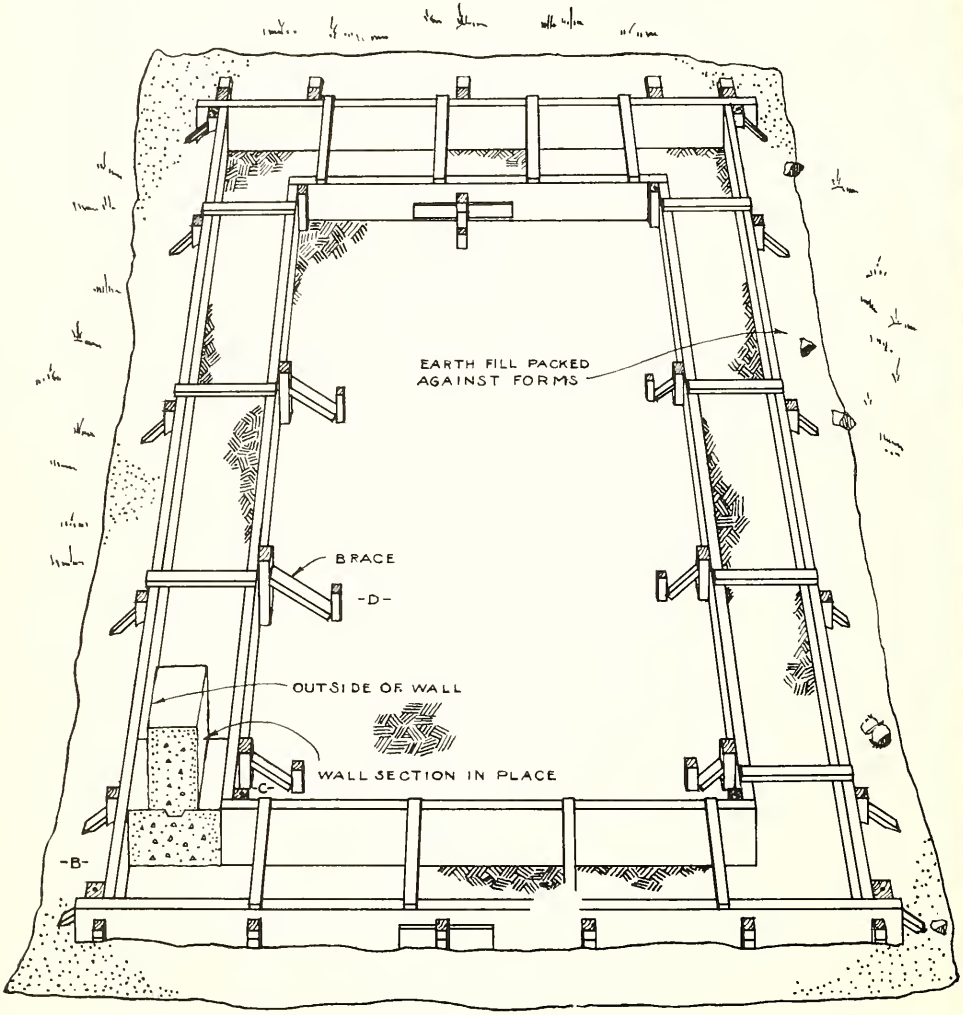


FIG. 10 FOOTING FORMS SET IN PLACE

DESCRIPTION OF FORMS FOR CONCRETE FOUNDATION WALLS

OBJECTIVES OF THE UNIT

1. To acquaint the learner with the method of making foundation walls by means of a single inside wall form and an outside trench bank.

2. To acquaint the learner with the method of making foundation walls by means of complete or double wall forms.

INTRODUCTORY INFORMATION

There are two general systems used in making forms for concrete walls. The less expensive of the two systems requires only an inside form. The complete or double form consists of form panels built for both sides of the wall.

INSIDE WALL FORMS

When the foundation walls come to the limits of the lot line, it is necessary to build only an inside form. The bank of the excavation serves as the outer form. However, this type of form should be avoided whenever possible, as it is very difficult to cut the banks straight and plumb. If the banks are not straight and plumb, it is necessary to use more concrete, which makes the wall more expensive. Also it is difficult to water-proof this type of wall from the outside.

Without an outside form, no wall ties can be used. This type of construction requires heavier bracing on the inside wall to compensate for this lack of wall ties.

The concrete should be poured in slowly and not from a great height as the higher the concrete falls, the greater the pressure is on the forms. All the inside surfaces of the form should be painted with a stainless grease, crude oil, soft soap, or white wash to prevent the concrete from sticking to the form.

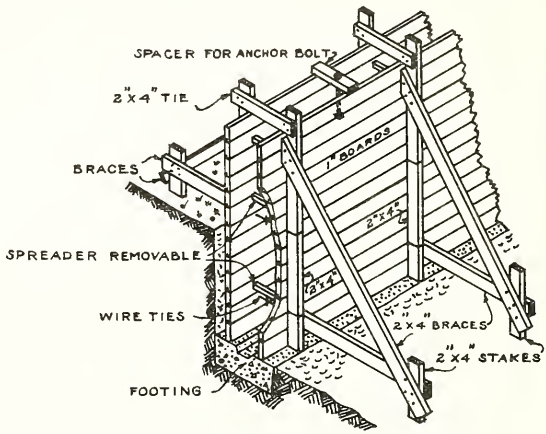
COMPLETE INSIDE AND OUTSIDE FORMS

When the foundation walls are well within the lot or property lines, forms for both the inside and outside of the wall should be used. With this type of form, a reasonably straight smooth wall is possible. When double forms are used, the excavation must extend beyond the actual building line. If the cellar is dug at least 12 in. outside each wall line, it will provide enough space for the outside form and also space to waterproof the wall with tar or other materials.

Forms should be built in sections that are not too heavy for four men to lift, and they should be erected and secured in such a way that

they may be removed from the hardened concrete wall without an excessive amount of hammering or pulling which might crack or deface the concrete. See Unit 1C-T22.

After the form sections have been made, they should be braced in position by walers and spreaders, and held to alignment by diagonal bracing. See Fig. 1. Wire is often used to tie the forms together at the spreaders. The spreaders should be removed as the concrete is poured into the forms. Otherwise the wooden spacers will form a blemish in the finished wall. Care and judgment should be used when twisting the wires in a form so as not to break them. Too much twisting will stretch the wire to a point close to its tensile strength, and the wire is likely to break under the pressure of the concrete load.



DOUBLE WALL FORM

FIG. 1

SELECTED REFERENCES

Alpha Cement - How to Use It ..... Alpha Portland Cement Co.

Concrete on the Farm ..... The Atlas Portland Cement Co.

A Vocational Course in Concrete ..... Portland Cement Association

Other Publications of the Portland Cement Association.....

HOW TO BUILD FORMS FOR FOUNDATION WALLS

OBJECTIVES OF THE UNIT

1. To show how to make a single wall form.
2. To show how to make double wall forms.
3. To show how to brace and align concrete forms.

INTRODUCTORY INFORMATION

That portion of the concrete wall below the surface of the ground may not require wooden forms for both sides of the wall unless the ground is porous or will not form a firm bank. Under favorable conditions, the earth bank may be used as a form for the concrete, but this type of form is not as satisfactory as one using an inside and an outside form. However, both types will be covered in this unit. It is assumed that the footings for the wall are in place.

TOOLS AND EQUIPMENT

Claw hammer
Crosscut saw
Spirit level
Chalk line
Steel tape
Steel square
Plumb bob
Wire cutters
Hand axe
Straight edge

PROCEDURE

HOW TO MAKE PANELS FOR SINGLE WALL FORMS

NOTE: If the wall is very long, make up the forms in panels, not over 10 ft. in length for easy handling.

1. Cut 2 x 4 studs long enough to reach the top of the proposed form.
2. Place two 12 ft. planks on top of a pair of saw horses. The planks may be 2 x 6 or larger.
3. Spread the planks on the horses so that the studs will lie across the planks.
4. Nail the two outside planks in place on the saw horses to keep them from moving.
5. Select a straight sheathing board and cut it to the length of the panel.

6. With a steel square, measure 24 in. from the left end of the board and make a mark. Square this mark across the board and make an X mark at the right of it (Fig. 1).

7. Using the body of the framing square, continue to lay out the location of the studs at 24 in. intervals across the board. Let the last stud come as it will. The marked board should look like A, Fig. 1.

8. Make a duplicate of this board as shown at B.

9. Place studs to correspond to the marks on the boards A and B.

10. Lay the board (A) on top of the studs with the marks up.

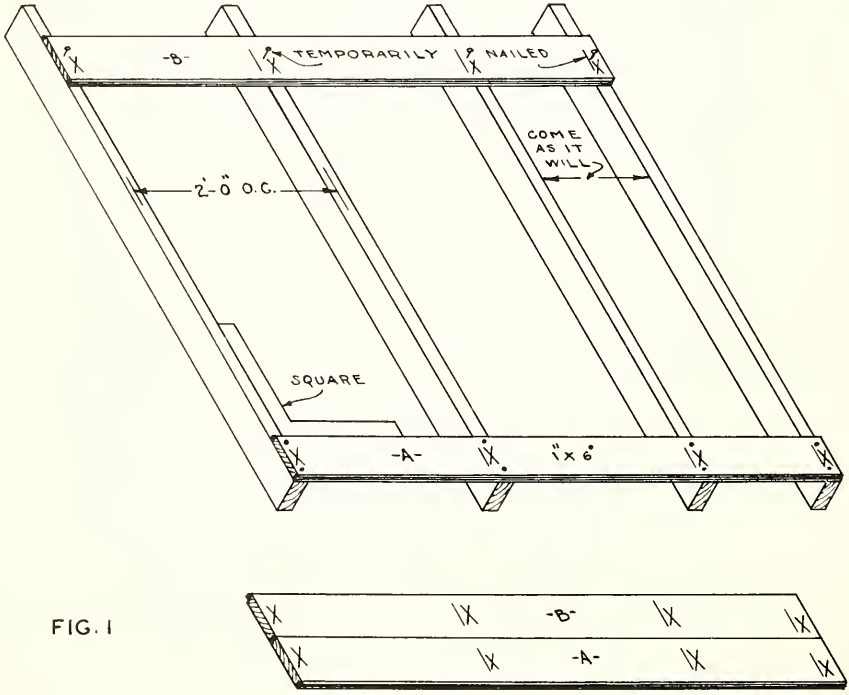


FIG. 1

METHOD OF ASSEMBLY OF A FORM PANEL

11. Fasten the board (A) to the stud on the left with one nail, placing the end of the board flush with the face of the stud (Fig. 1).

    NOTE: If a shoe is to be used at the bottom of the form, nail the board (A) to the bottom end of the studs instead of to the face of the studs as shown. Nailing a shoe on the end of the studs makes the panel more rigid and also simplifies the aligning of the panels on the footing.

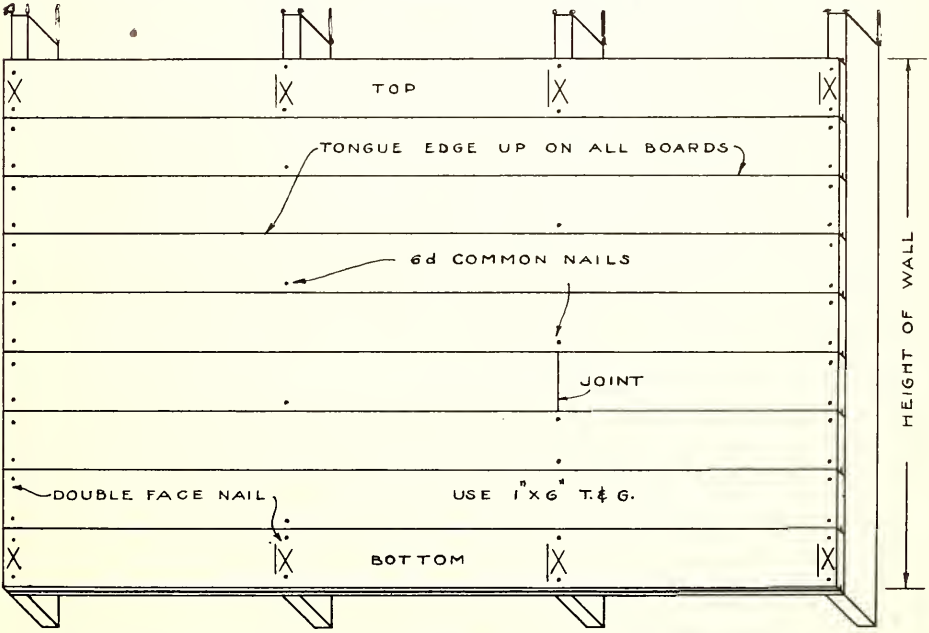
12. Nail the other end of the board (A) in the same manner.

13. Nail the board to the remaining studs, after having placed them on the side of the line marked X.

14. Place the tongue of the square on the upper edge of the board with the body up the side of a stud, and move the stud until it is square with the board. Nail the board and stud solidly together. Continue in this manner until all studs have been nailed square with the first sheathing board.

15. Tack board (B) temporarily to the top of the studs to hold them in position.

FIG. 2 METHOD OF NAILING PANELS



HOW TO NAIL THE SHEATHING

1. Nail the sheathing to the studs, keeping all boards tight and using 6d common wire nails.

2. Nail each sheathing board on every other stud as shown in Fig. 2.

3. Nail only the groove edge of the sheathing boards on the inside studs. Double nail the top and bottom boards and also the ends of every board.

4. If a joint occurs in the sheathing, place a nail directly over and below the joint on the adjacent boards.

HOW TO SET THE FORMS ON THE FOOTING

1. Using a plumb bob, mark points on the footing directly below the building line or outside face of the wall (Fig. 2, Unit 1C-P21).

2. From these points, locate the inside of the wall on the footing.

3. At these points, snap a chalk line on the footing. These lines should run the full length of the footing.

   NOTE: Another method of locating the panels on the footing is described in Unit 1C-P23.

4. On this line, drive 8d nails part way in the footing. The nails should be about 6 ft. apart.

5. Set the form panels in place against these nails.

6. Brace the bottom of the form to the footing by driving stakes into the ground along the outside edge of the footing as shown in Fig. 1, Unit 1C-P23.

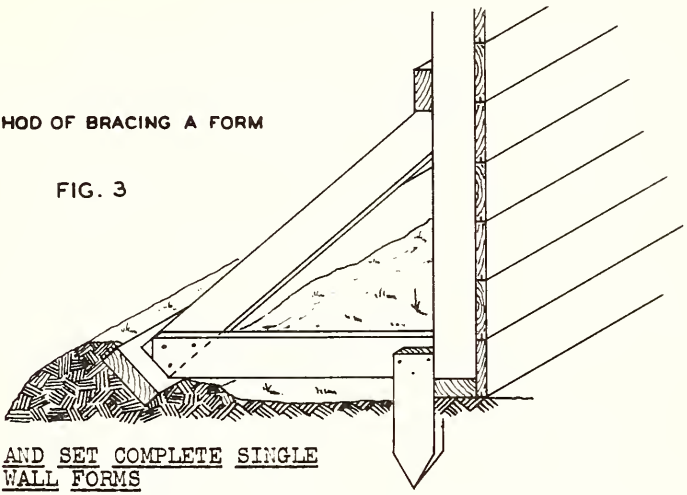
7. Brace the sides of the form panels temporarily.

8. Proceed in similar fashion, erecting each form.

9. Place the walers along the sides of the form panels and place the diagonal side braces about 4 ft. apart.

10. Align the panels and plumb them opposite each brace.

    NOTE: It is sometimes good procedure to embed a plank in the ground and pack earth firmly around it. The diagonal braces are then nailed against the face of the plank as shown in Fig. 3.



A METHOD OF BRACING A FORM

FIG. 3

HOW TO MAKE AND SET COMPLETE SINGLE WALL FORMS

NOTE: Assume that panel forms are to be built for a building 20 ft. wide and 100 ft. long, the wall being 12 in. thick and 4 ft. high. The inside dimensions of the wall would be 18 ft. by 98 ft.

1. Make twenty panels, as previously described, 10 ft. long and 4 ft. high. Nine of these will be used for each side of the excavation and two for the ends.

2. Make four panels 8 ft. long and 4 ft. high. One of these will be used for each end and one for each side.

3. Set the panels on the footing and brace and align them as previously described.

HOW TO MAKE PANELS FOR DOUBLE WALL FORMS

1. To build a panel 10 ft. long and 4 ft. high, (or the height of the wall) cut two pieces 2 in. x 4 in. x 10 ft. These are for the top and bottom plates.

2. Cut six pieces 2 in. x 4 in. x 3 ft. 8 3/4 in. These are for the uprights or studs (Fig. 4).

3. Nail the framework together, spacing the studs 24 in. on centers.

4. Square the framework and brace it so it will stay square while the sheathing is being nailed.

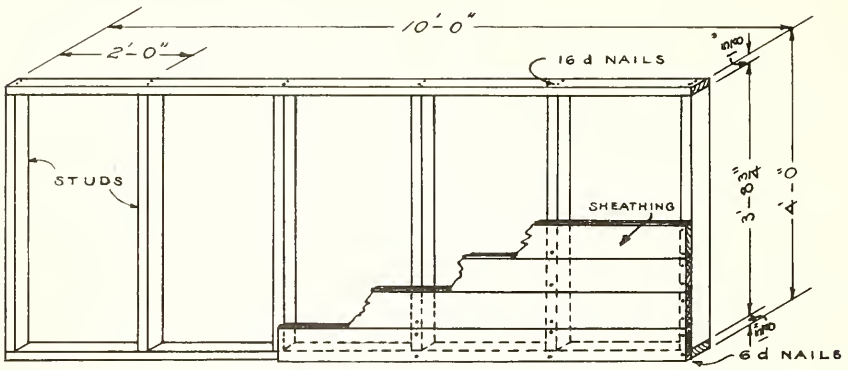


FIG. 4 - BUILDING A FORM PANEL

5. Apply the sheathing, being careful to keep the ends flush with the outside edges of the two end uprights (Fig. 4).

HOW TO MAKE COMPLETE DOUBLE WALL FORMS

NOTE: The type of form herein described may be used repeatedly in duplicate or near duplicate buildings. It is assumed that forms are to be built for a building 20 ft. x 100 ft. All panels are to be 4 ft. high.

1. Make twenty panels, as described above, each 10 ft. long, for the two outer side walls.

2. Make two panels 10 ft. long and two 10 ft. 9 in. long. One of each of these is to be used for each outside end wall.

NOTE: These lengths are arrived at as follows: As the end forms for the outside of the wall project over the concrete line of the side forms, $4\frac{1}{2}$ in. must be added to each end panel (A, Fig. 5). Thus the outside end forms described in Step 2 should be 20 ft. plus $4\frac{1}{2}$ in. plus $4\frac{1}{2}$ in. or a total length of 20 ft. 9 in. This can be divided up conveniently into two panels, one 10 ft. long and one 10 ft. 9 in.

3. Make two panels 10 ft. long and two panels 7 ft. $10\frac{1}{2}$ in. long. One of each of these is to be used for each inside end wall.

NOTE: To arrive at the length of these panels, subtract the combined thickness of the two sidewalls (2 ft.) from the width of the building (20 ft.), obtaining 18 ft. From

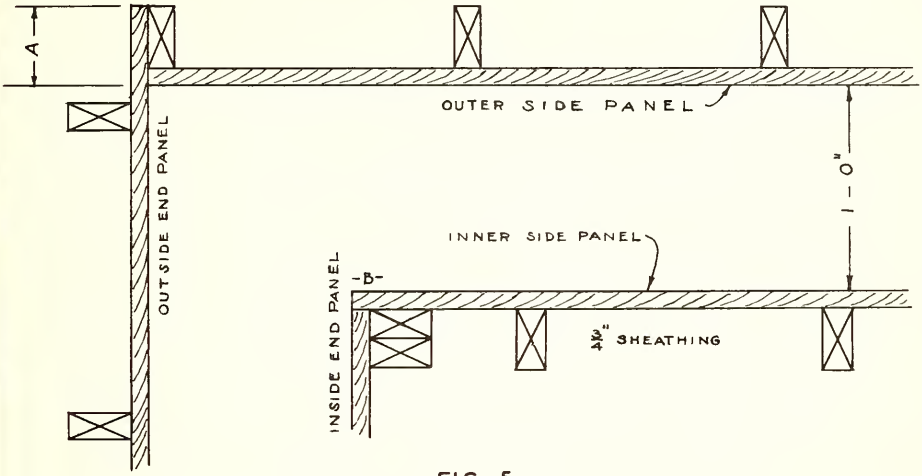


FIG. 5

PLAN VIEW OF FORM AT CORNER

this figure, subtract the combined thickness of the sheathing on each of the two sidewalls (1½ in.) (Fig. 5). The result, 17 ft. 10½ in., is the total length of this form and may be conveniently divided into two panels, one 10 ft. long and one 7 ft. 10½ in. long.

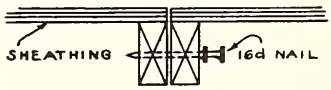
4. Make eighteen panels 10 ft. long and two panels 8 ft. long for the inner sidewalls. Omit one end stud from each of four of the 10 ft. panels to allow for nailing the side panel to the end panel. See B, Fig. 5.

NOTE: The total length of each inner sidewall is 98 ft. (the length of the building, 100 ft., minus the combined thickness of the two end walls, 2 ft.). Therefore, each side may be made up of nine 10 ft. panels and one 8 ft. panel.

5. Grease or oil the inside faces of all panels.

HOW TO BRACE AND ALIGN THE DOUBLE WALL FORMS

1. Set the outside wall panels in place on the footing, bracing them temporarily against the outside of the excavation. The panels may be spiked together (Fig. 6) or clamped.



METHOD OF FASTENING PANELS TOGETHER

FIG. 6

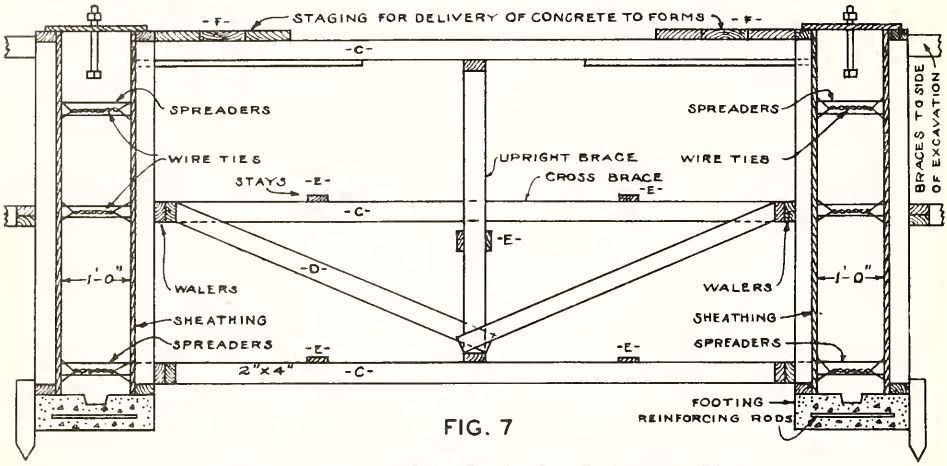


FIG. 7

SECTION SHOWING BRACES OF DOUBLE WALL FORM

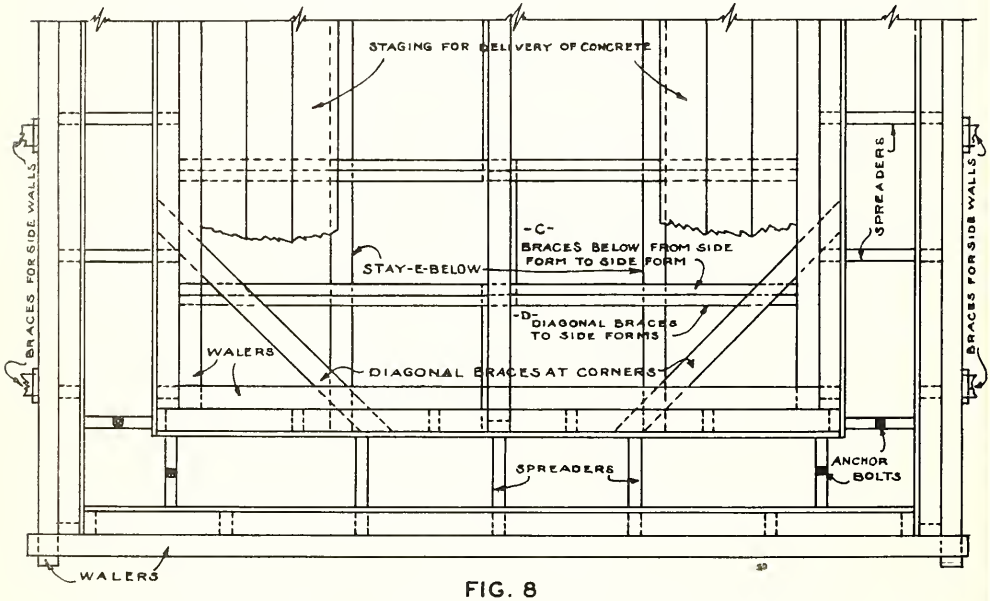


FIG. 8

PLAN VIEW SHOWING BRACES ON DOUBLE WALL FORMS

2. Provide the necessary holes for the type of spreaders and ties that are used in the panels.

3. Erect the inside panels in a like manner. Double the inside corner studs as shown at B, Fig. 5. Hold the panels in position by the braces C and D and the stays E, Figs. 7 and 8. Place these braces every 4 ft. the length of the wall but nail them only temporarily until after the walers and wall ties have been put in place as described in Unit 1C-P23.

NOTE: Figure 9 shows another view of the double wall with walers, tie wires and wooden spreaders in place. Notice how the panel joints on the opposite sides of the wall form are staggered.

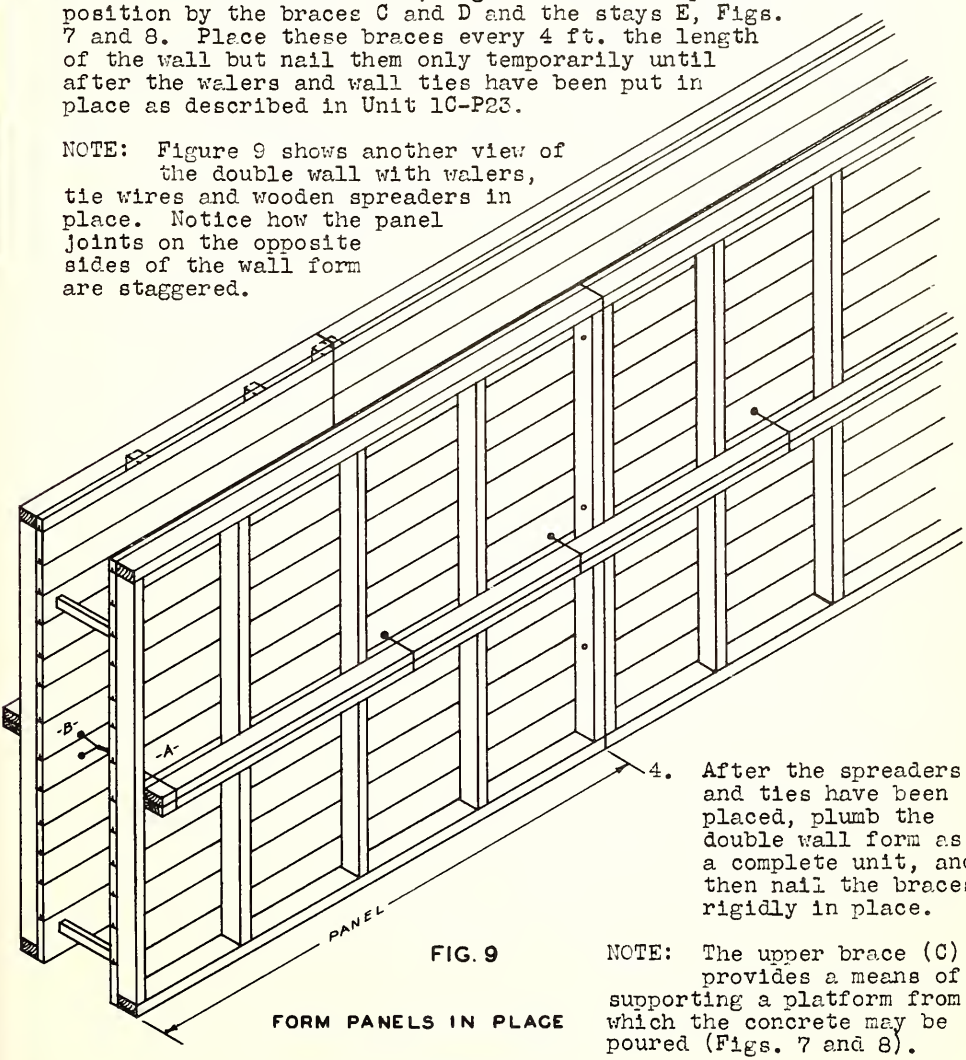


FIG. 9

FORM PANELS IN PLACE

4. After the spreaders and ties have been placed, plumb the double wall form as a complete unit, and then nail the braces rigidly in place.

NOTE: The upper brace (C) provides a means of supporting a platform from which the concrete may be poured (Figs. 7 and 8).

HOW TO MAKE DOUBLE WALL FORMS WITH CLEATED PANELS

1. Make the panels any convenient length as shown at A, Fig. 10. The width of the panel may vary according to the type of wall.

2. Space the cleats (B-B) so they come between the studs of the form framework as shown in the assembled form (Fig. 10).

3. Cut the studs as described in building a single wall form.

4. Nail the cleated panels to the studs. Stagger the joints of the panels on the studs.

5. The remaining procedure is similar to that used in building the other type of forms.

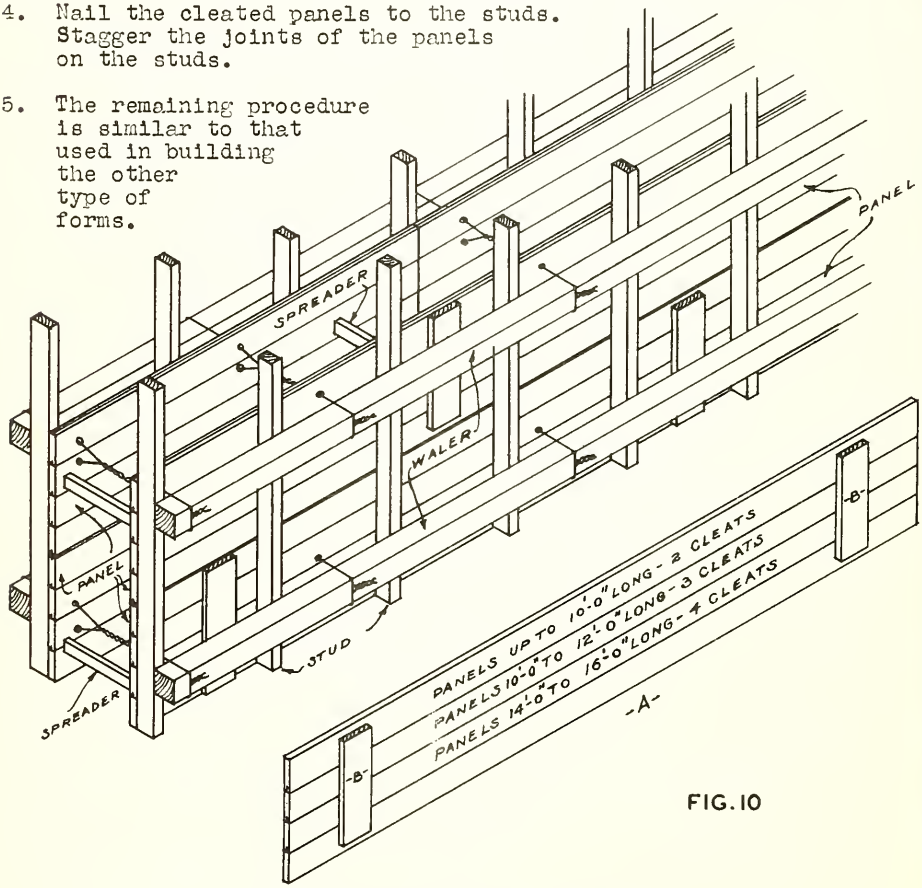


FIG. 10

FORMS MADE WITH CLEATED PANELS

DESCRIPTION OF OPENINGS IN CONCRETE WALLS

OBJECTIVES OF THE UNIT

1. To point out the method of providing for openings in concrete walls.
2. To describe methods used to insure easy removal of forms for openings.
3. To describe the method of inserting finished cellar window frames in forms for concrete.

INTRODUCTORY INFORMATION

In continuous concrete walls, provision must be made in the wooden forms for openings for windows, electric conduits, water pipes, sewer pipes, and bearing seats for girders.

HOW OPENINGS IN CONCRETE WALLS ARE FORMED

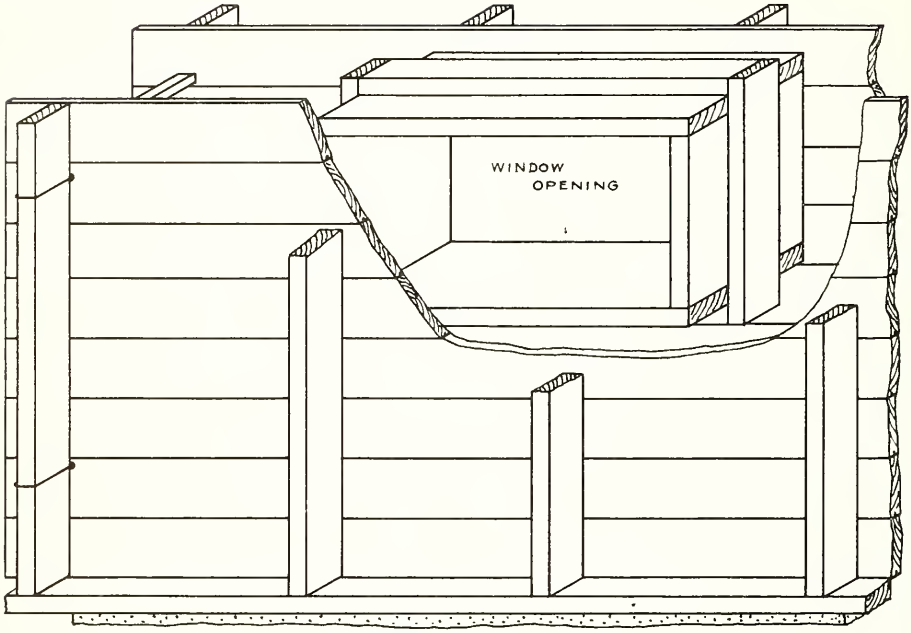
Openings are formed by making rectangular box-like forms of wood to the size of the openings to be left in the concrete wall. These box forms are fastened between the wooden forms of the wall so that the concrete, when poured into the forms, will surround the box form, thereby leaving a space in the wall where no concrete can enter. This, in turn leaves a void in the wall the size of the box form (Fig. 1).

Wood is generally used in making rectangular forms for openings in walls, while sheet metal and the newer type of plywood are used for circular or irregular forms.

Openings for conduits, pipes and other supply lines should be so placed that they will do no structural harm to the concrete wall by weakening it. If it is necessary to place such an opening in a vital part of the wall, the concrete should be reinforced to take up the strain.

METHODS USED TO INSURE EASY REMOVAL OF FORMS FOR OPENINGS

These box forms must be constructed in such a manner that they may be removed from the wall after the concrete has hardened. Greasing the surfaces of the forms that are to come in contact with the concrete will make this removal easier by preventing the concrete from sticking to the wood. These forms should be built with a slight taper toward one wall. This makes it possible to slip the box out of the larger end of the hole after the concrete has set. The box-like forms may also be made so that they are collapsible and can be taken apart while still in the hardened concrete wall.



FORM FOR OPENING IN WALL

FIG. 1

INSERTING FINISHED CELLAR WINDOW FRAMES IN FORMS

The finished cellar window frame is often placed in the form before the concrete is poured. This method saves the building of forms for the window opening. The frame should be set in the proper place and filler strips placed between the form and the edge of the frame to keep the concrete from running into the frame. See Fig. 8, Unit 1C-P27.

SELECTED REFERENCES

A Vocational Course in Concrete ..... Portland Cement Association

Concrete on the Farm ..... The Atlas Portland Cement Co.

Alpha Cement - How to Use It ..... Alpha Portland Cement Co.

HOW TO PROVIDE FOR OPENINGS IN CONCRETE WALLS

OBJECTIVES OF THE UNIT

1. To show how to make forms for small openings in concrete.
2. To show how to make frames for door or window openings in concrete.
3. To show how to install finished cellar window frames in forms.

INTRODUCTORY INFORMATION

Forms for openings in concrete walls must be so planned and constructed that they will provide for the opening in the proper place and of the correct size. These forms must keep all concrete out of the openings and, in some cases, must withstand considerable pressure from the concrete.

TOOLS AND EQUIPMENT

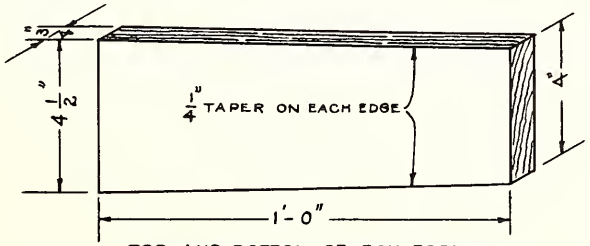
Hammer
Crosscut saw
Try square
Pencil
Rule
Grease, soap, crude oil or linseed oil
Spirit level

PROCEDURE

HOW TO MAKE A BOX FORM

NOTE: Assume that it is desired to make a form for an opening for a support running into the wall or a pipe through the wall. The opening is to be 4 in. by 4 in. in a 12 in. concrete wall.

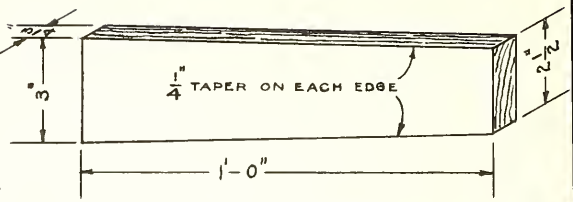
1. Cut two pieces 3/4 in. x 4 1/2 in. x 12 in. and taper them as shown in Fig. 1. These are to be used for the top and bottom of the box form.



TOP AND BOTTOM OF BOX FORM

FIG. 1

2. Cut two pieces 3/4 in. x 3 in. x 12 in. and taper them as shown in Fig. 2. These are to be used for the two sides of the box form.



SIDES OF BOX FORM

FIG. 2

3. Assemble the four pieces as shown in Fig. 3, using 6d nails. The assembled box should then measure approximately 4 in. x 4 in. on one end, and 4 1/2 in. x 4 1/2 in. on the other.

4. Round off the outside corners of the box.

5. Cover the outside surface of the box with grease or similar material.

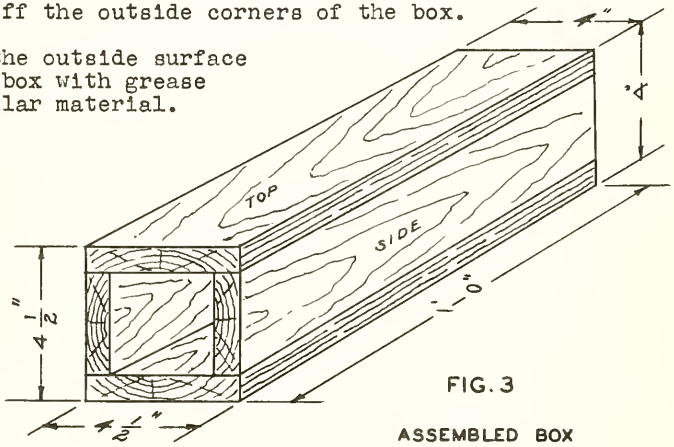


FIG. 3

ASSEMBLED BOX

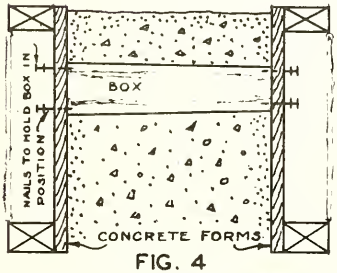


FIG. 4

BOX IN CONCRETE WALL

6. Place the box form in the proper position in the concrete forms (Fig. 4).

7. Hold the box in position in the form by driving nails through the sheathing into the ends of the box. Do not drive the nails all the way into the wood, but allow the heads to stick out beyond the surface so they can be pulled out easily when taking the forms off the concrete wall (Fig. 4).

HOW TO MAKE FRAMES FOR DOOR OR WINDOW OPENINGS IN CONCRETE WALLS

1. Mark the height of the sash (19 in. in this case) on the inside edge of each side jamb (Fig. 5). These points mark the inside lines of the head and sill dado joints. Allow about 3 in. on each end of the jambs to provide for the dado joints and the horns (Fig. 6).

2. Lay out the dadoes 1 5/8 in. wide and 3/8 in. deep for the head jamb. These dadoes are square across the boards.

3. Lay out points for dadoes of the same size for the sill, on the inside edges of the side jambs. Be sure to lay out one right and one left jamb.

4. Mark the dado lines across the faces of the boards, using the sliding T bevel set at 5° to 8°. This angle will provide for the pitch of the window frame sill.

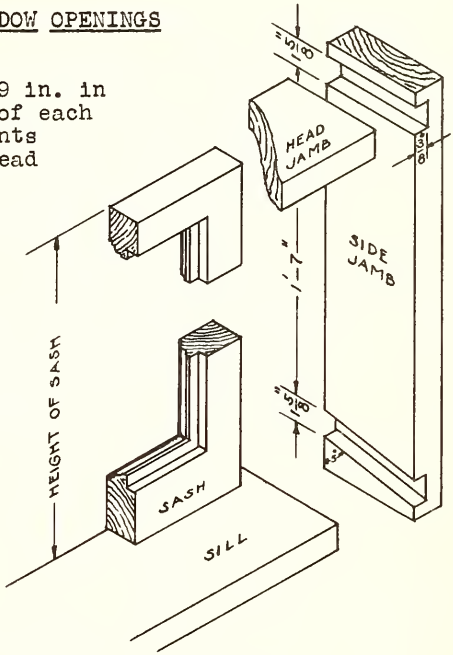


FIG. 5

LAYOUT OF SIDEJAMB

5. Cut the four dadoes on the two side jambs.

6. Cut the head jamb and sill 7/8 in. longer than the outside width of the sash. This extra length is added to allow the head jamb and sill to be set into the dadoes which are each 3/8 in. deep. The additional 1/8 in. permits the completed frame opening to be left 1/8 in. oversize since the sash comes considerably larger than necessary. This saves extra planing in fitting the sash.

NOTE: When the glass size of the window is shown on the plans or is known, the outside size of the sash is figured as follows:

Assume that it is necessary to determine the outside size of a cellar sash of three lights each 12 in. wide and 14 in. high.

A. To find the outside finished width of this sash, multiply the width of the glass (12 in.) by the number of lights (3). To this, add 1/4 in. for each of the two muntin bars between the glass. Also, add 2 in. for each side rail. Thus the width of the sash is 40 1/2 in.

B. To find the outside finished height of the sash, add together the height of the glass (14 in.), the width of the top rail (2 in.) and the width of the bottom rail (3 in.). Thus the height of the sash is 19 in.

NOTE: If 1 5/8 in. side jambs are used, casings are not needed. If 3/4 in. jambs are used, casings should be provided and the jambs should be braced so they will not bow from the pressure of the concrete. Jambs which are 1 5/8 in. thick are the ones most commonly used for cellar frames.

NOTE: When provision is to be made for door openings in concrete walls, the procedure is similar to that used for window openings. Care must be taken, however, to see that the side jambs or bucks of the door frames are braced so the concrete will not bow them out of plumb.

HOW TO ASSEMBLE THE FRAME

1. Set the head jamb and sill into the dadoes in the side jambs. Nail through the side jambs into the head jamb and sill (Fig. 6).

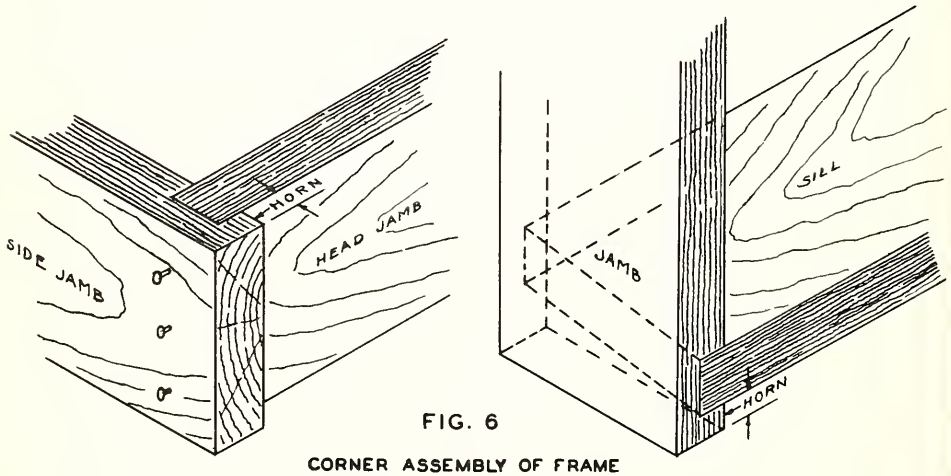


FIG. 6
CORNER ASSEMBLY OF FRAME

2. Square and brace the frame as shown at A, Fig. 7.

3. Cut off the horns at the ends of the side jambs if necessary (Fig. 6). The bottom horns should be cut square across rather than at an angle.

4. Nail strips to the outside of the side jambs and sill to hold the frame in the concrete (B and C, Fig. 7).

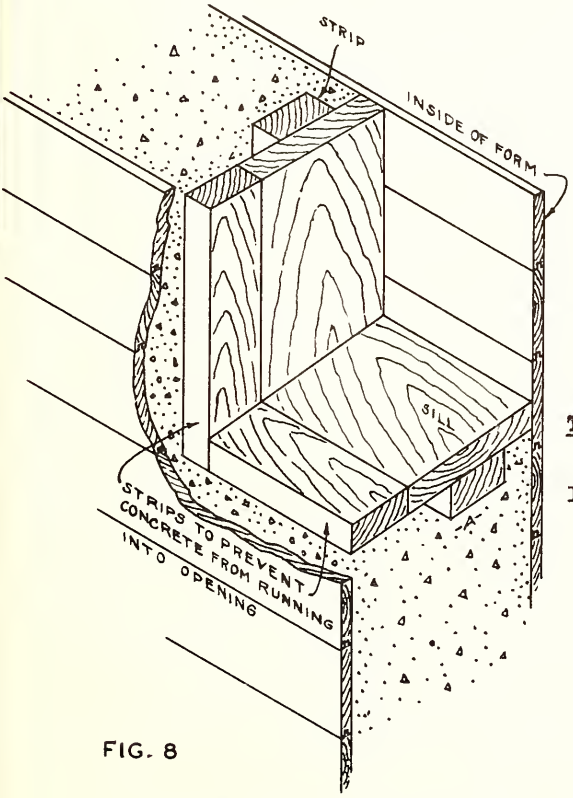


FIG. 8

CELLAR FRAME IN CONCRETE FORM

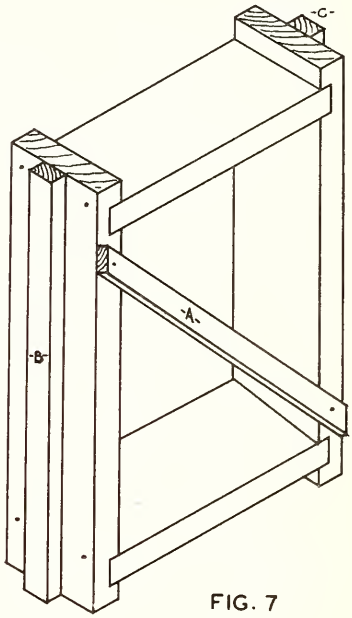


FIG. 7

ASSEMBLY OF FRAME

TO INSTALL THE FRAME IN THE FORM

1. Nail the frames in position in the forms as in Fig. 1, Unit 1C-T27. If the side jambs of the frame are narrower than the inside width of the form, the frame may be nailed to the inside or outside form as desired, and pieces of 2 x 4 may be nailed in the gaps between the frame and the form. This will prevent concrete from running into the frame opening. See Fig. 8.

NOTE: When a finished window or door frame is to be set in a concrete wall after the wall has been poured, a temporary frame or buck is placed in the form. Bevel shaped key strips should be tacked on the outside of the buck. These strips remain in the hardened concrete after the buck has been removed from the wall, to provide a nailing surface for the finished frame.

DESCRIPTION OF FORMS FOR CONCRETE STEPS

OBJECTIVES OF THE UNIT

1. To point out advantages of concrete steps over wooden steps.
2. To describe the method used to build steps on sloping ground.
3. To describe the method used to build the open type of steps.
4. To describe methods used to ornament risers and to provide safety treads.

INTRODUCTORY INFORMATION

Concrete steps are superior to wooden steps for outside approaches. This is especially true where the grade level changes, such as in terraces, or where the steps are embedded in the ground. This type of step is also used in outside hatchways to cellars where the stairway is subjected to hard use.

Concrete steps will not rot, they are more permanent than wooden steps and are easier to keep clean. They can be provided with safety treads by sprinkling powdered carborundum on the treads just before the concrete sets. Concrete steps can also be made waterproof by a coating painted over the surfaces. Iron hand rails and nosings can be installed solidly in the concrete treads or sidewalls to provide a safe stairway.

TYPES OF CONCRETE STEPS

There are two general types of concrete steps. One type is built directly on the slope of the ground, while the other is supported at the top and the bottom, leaving an air space under the steps.

STEPS BUILT ON SLOPING GROUND

This type of step is sometimes built between concrete walls. The wooden forms for such a wall are constructed in much the same manner as those of a regular continuous wall. After the concrete in the sidewalls is hard enough to permit removal of the forms, the inside form of each sidewall is carefully removed. The forms that are to be used to form the risers and treads of the steps are then built between the sidewalls (Fig. 1).

Blocks are nailed to the hanging stringers (Fig. 1) along the layout marks for each tread and riser. The riser boards are then nailed to these blocks. The slope of the ground is often stepped off so the concrete will not slide along the bed of the steps.

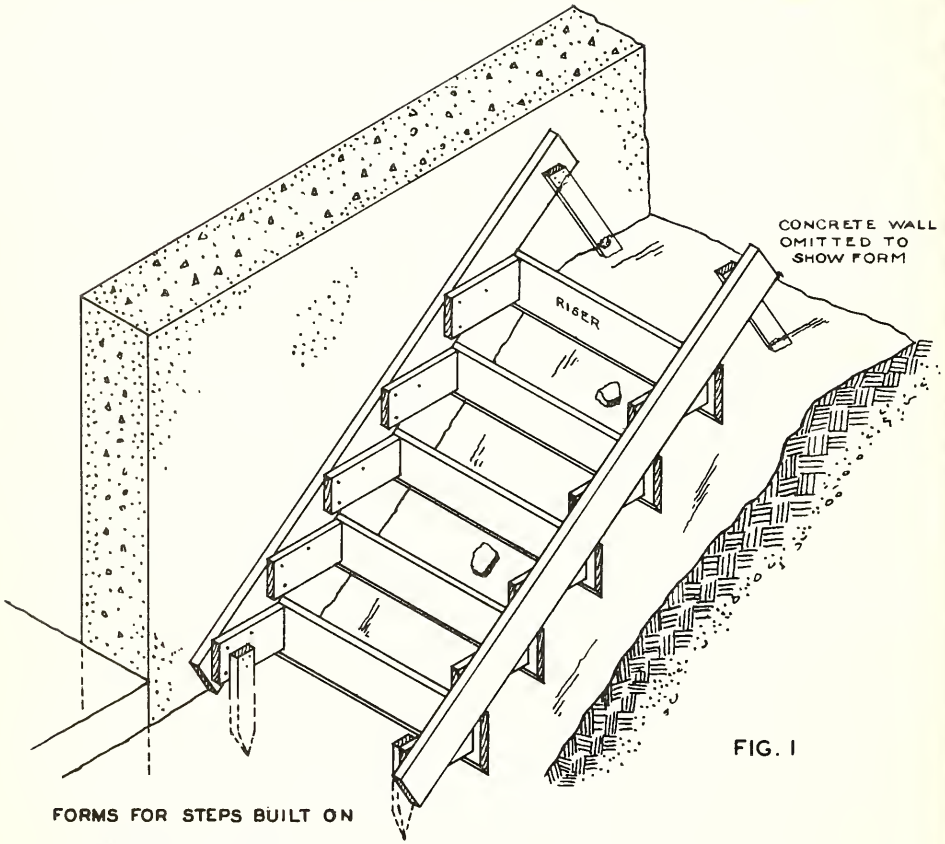


FIG. 1

FORMS FOR STEPS BUILT ON SLOPING GROUND

Another example of steps built on sloping ground is shown in Fig. 2.

The soil must be well drained under this type of step so water cannot accumulate underneath them. If the soil is clay, a well tamped layer of cinders should be placed underneath the 4 in. concrete bed of the steps.

Figure 2 shows a completed concrete stairway for an outside entrance to a cellar.

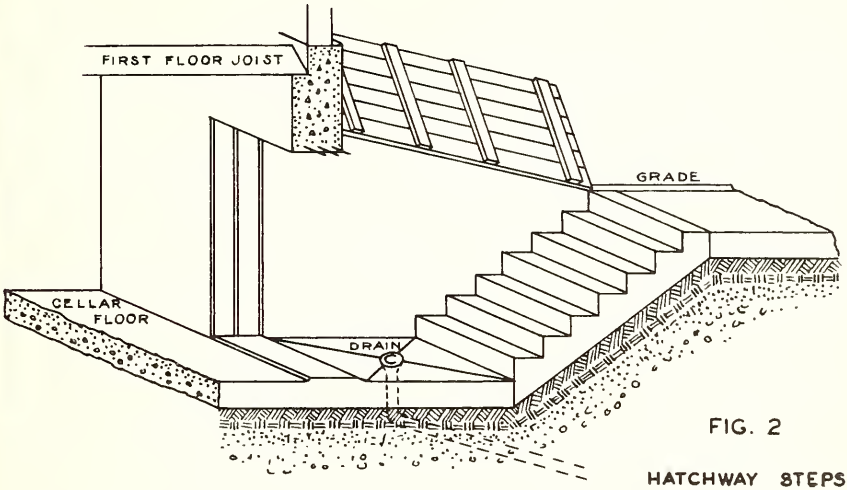


FIG. 2

HATCHWAY STEPS

THE OPEN TYPE OF STEPS

The forms for the open type of concrete steps (Fig. 3) are somewhat more difficult to build.

A wooden platform of tongue and groove sheathing is built to support the bottom or supporting slab of the stairs. See Fig. 4. This panel extends about 12 in. beyond each side of the stairs to provide a support for stringer bracing blocks. The back of the panel should be well braced and supported by 4 x 4's. These should rest on wedges to permit easy adjustment and to simplify the removal of the posts.

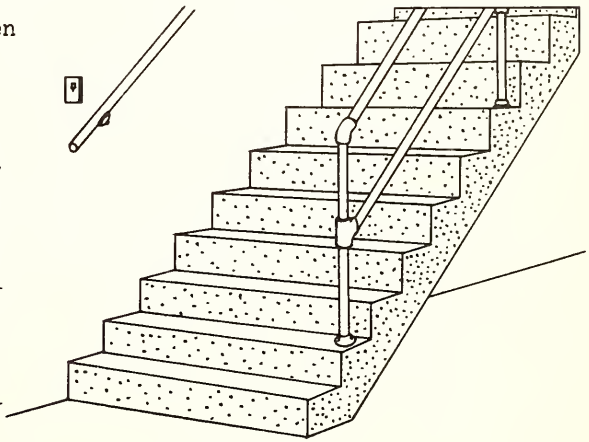


FIG. 3

OPEN CONCRETE STEPS

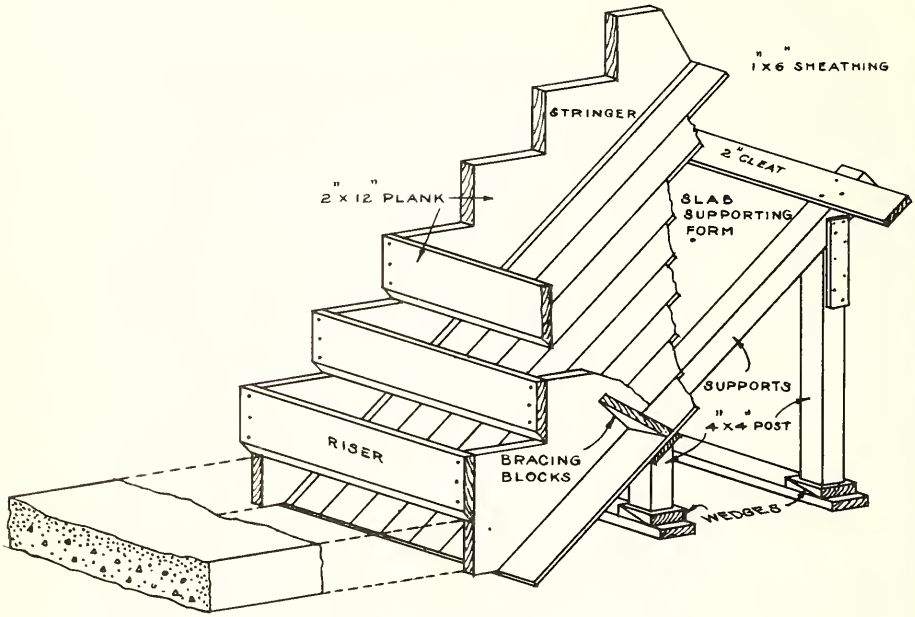


FIG. 4

FORMS FOR OPEN CONCRETE STEPS

The side stringers are laid out in the same manner as the supporting carriage for a flight of wooden stairs and are cut from a 2 in. x 12 in. plank. The pieces that are cut out may be saved and nailed to a piece of 2 x 4 or 2 x 6 to make an additional stringer if needed.

Figure 5 shows another method of building forms for steps of long span, or subject to heavy service.

Reinforcing rods should be placed 1 in. from the surface of the form supporting the slab (Figs. 4 and 5). The rods should run lengthwise up the platform and should be spaced as shown in the table in Fig. 6. The location of these rods in the finished steps is shown in Fig. 7.

It is customary to remove the side forms and riser forms about 24 hours after the concrete has been poured, so the troweled finishing coat of cement will bond with the faces of the treads, risers and side walls. The supporting forms, such as the platform and the shoring, should remain intact about three weeks.

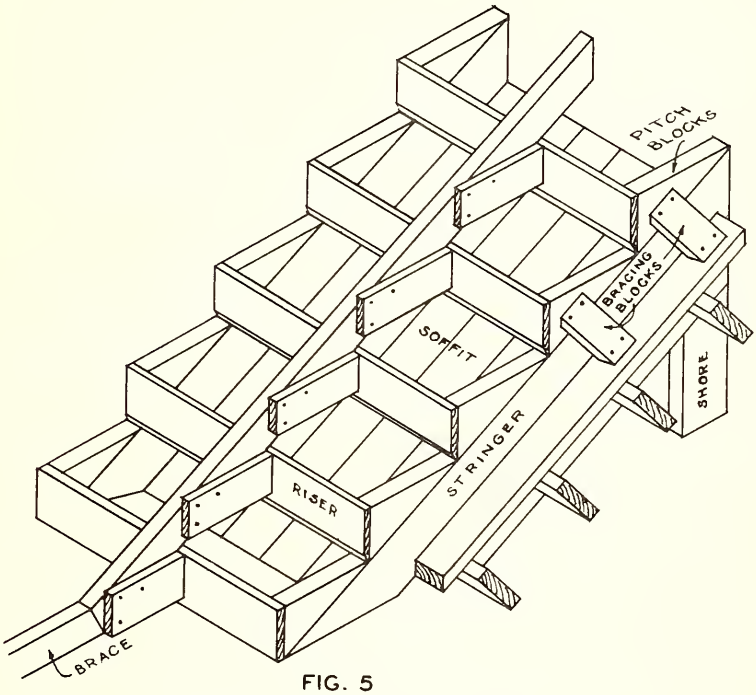


FIG. 5

FORMS FOR HEAVY DUTY STEPS

TABLE OF REINFORCEMENT FOR CONCRETE STEPS					
No. of Steps	Clear Span		Thickness Slab	Reinforcement	
				Diameter	Spacing Rods
	Feet	Inches	Inches	Inches	
4	2	2	4	1/4	10 inches
5	3	0	4	1/4	10 inches
6	3	10	4	1/4	7 inches
7	4	8	5	1/4	7 inches
8	5	6	5	1/4	5 inches
9	6	4	6	1/4	5 inches
10	7	2	6	3/8	5 inches
11	8	0	6	3/8	6 inches

FIG. 6

STAIR RISER FORMS

There are several different types of forms for risers of concrete stairs. The most common type (Fig. 8A) is made from a straight plain board and forms a plain faced concrete riser. At B the same type of board is used, but it is tilted so as to form an undercut concrete riser face. At C the riser board is built up of two pieces so as to give the concrete riser face an ornamental or panel effect.

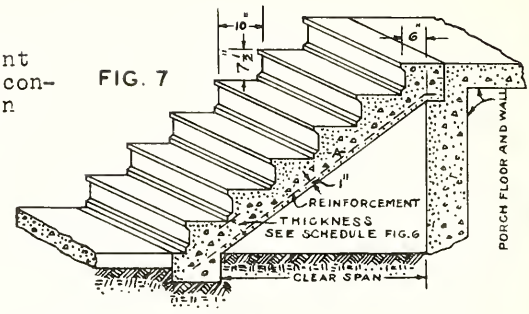
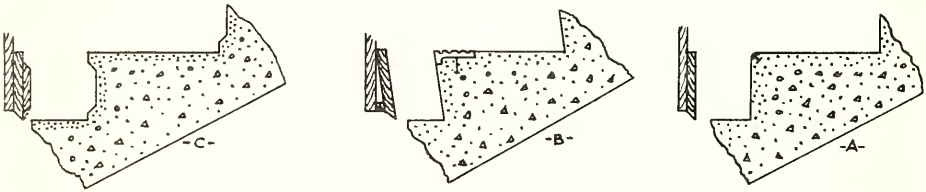


FIG. 7

SECTION OF STEPS SHOWING REINFORCING RODS

The bottom edge of all the riser boards is beveled to allow the mason to trowel the face of the tread back to the face of the riser while the forms for the risers are still in place.



DETAIL OF STEP TREADS AND FORMS

FIG. 8

SELECTED REFERENCES

Concrete on the Farm ..... The Atlas Portland Cement Co.

Wood Construction ..... National Committee on Wood Utilization

HOW TO BUILD FORMS FOR CONCRETE STEPS

OBJECTIVES OF THE UNIT

1. To show how to build forms for steps on sloping ground.
2. To show how to build forms for open steps.

INTRODUCTORY INFORMATION

The safety and appearance of concrete steps is dependent largely on the quality of workmanship on the forms. This type of work requires accurate planning and a knowledge of stair layout. The two general types of stair forms herein described cover most of the situations encountered in ordinary wooden frame structures.

TOOLS AND EQUIPMENT

Hammer
Rip saw
Crosscut saw
Spirit level
Straight edge
Pinch bar
Wire cutters
Brace and 1/4 in. bit
Steel square
Rule
Plane
Wire and Wedges

PROCEDURE

HOW TO BUILD STEP FORMS ON SLOPING GROUND

NOTE: Figure 1 shows the forms in place between side walls. The forms for the side walls are made of panel sections similar to those described in Unit 1C-P25. The aligning, bracing, and spacing is also the same as in the construction of forms for a continuous concrete wall.

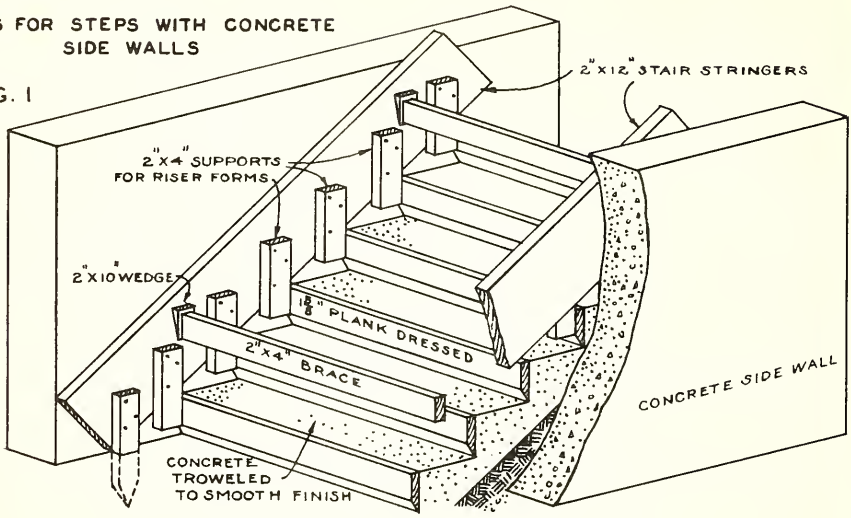
A. HOW TO FIND THE RISE AND RUN OF THE STAIRS

NOTE: Figure 2 shows a section of the side wall of Fig. 1. The point A represents the head of the steps and the upper sidewalk level. The point B represents the starting point of the steps and the lower sidewalk level. The distance A-C represents the run or horizontal length of the stairs.

1. Extend a level line on the side wall from point A as shown in Fig. 2.
2. From point B, mark a plumb line on the wall, extending it so it intersects the level line from point A. This establishes point C.
3. Measure the vertical distance between points B and C. In this case it is 42 in. This represents the total rise of the stairs.

FORMS FOR STEPS WITH CONCRETE SIDE WALLS

FIG. 1



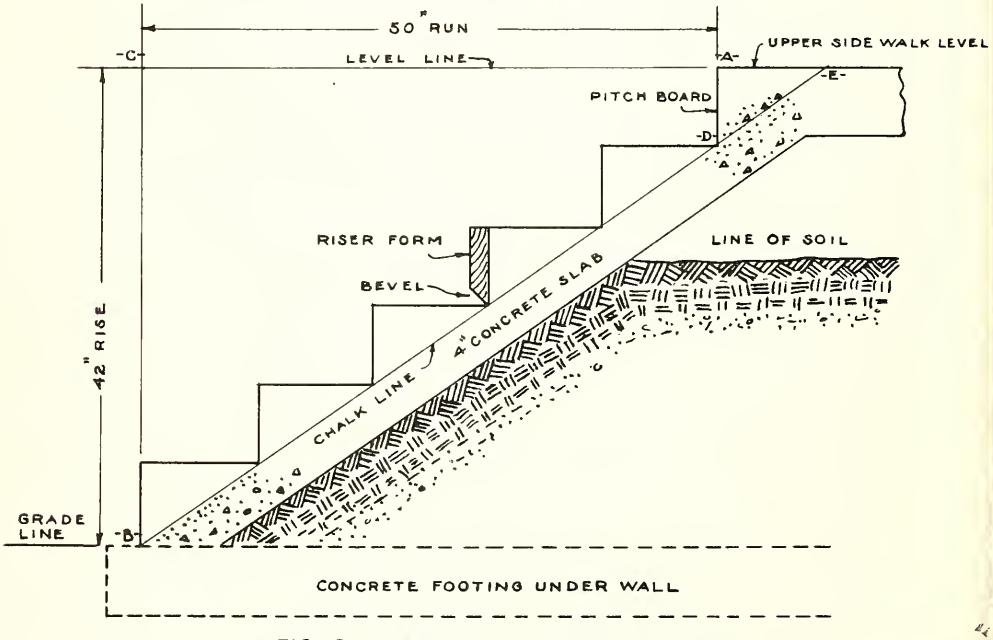


FIG. 2 LAYOUT OF CONCRETE STEPS

4. To find the riser height, divide 42 in., the total rise of the stairs, by 7 in., the allowable height of each riser for outside stairs. The result, six, is the number of risers required.

   NOTE: If the total rise of the stairs is in inches and fractions of an inch, lay the total rise off in equal divisions by using dividers. This will give the height of each riser and the number of risers required. Care should be taken to make the divisions 7 in. or less.

5. Determine the width of the tread.

   NOTE: A good method of proportioning risers and treads is to add to any given height of riser, that number which will make a total of twelve, double the number added, and the result will be the width of the tread.

   To find the width of the tread in this case, add to the rise, that number which will make a total of twelve (7 + 5 = 12). Double the number added to the rise (5 x 2 = 10) and the result, 10, will be the required width of the tread.

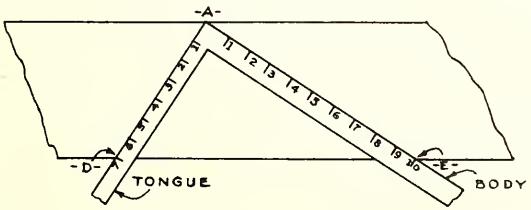
   If the number of risers and the total run of the stairs are definitely fixed, the width of the tread may be found by dividing the run (50 in.) by the number of risers (5). Thus the width of the tread will be 10 in.

   The number of treads required is always one less than the number of risers.

B. HOW TO MAKE AND USE A PITCH BOARD

1. To make a pitch board (Fig. 4), lay the steel square on a piece of 1 in. x 8 in. stock so the figures 7 on the tongue and 10 on the body of the square coincide with the edge of the board as at D and E, Fig. 3.

FIG. 3



PITCH BOARD

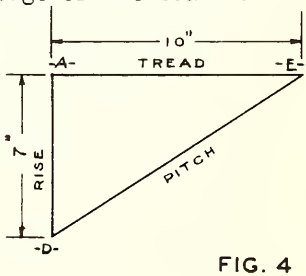


FIG. 4

2. Mark the lines AD and AE on the board along the tongue and body of the square.

3. Cut on these lines and the result will be a pitch board as shown in Fig. 4.

4. Plumb down from point A, Fig 2 a distance equal to the height of a riser. This locates point D.

5. To mark the pitch of the steps, connect points B and D, Fig. 2 by snapping a chalked line on the face of the concrete side wall. Extend this line from D so it meets the upper sidewalk level at E.

6. Place the pitch board on the concrete side wall in such a position that the point E, Fig. 4, lies directly on point E, Fig. 2, and that the line DE, Fig. 4, coincides with the line EDB, Fig. 2.

7. Mark the wall by scribing along the outside edges of the pitch board. The 10 in. edge represents the tread of the steps and the 7 in. edge represents the rise.

8. Repeat this procedure down the line EDB, Fig. 2, until all the steps have been marked.

9. Repeat steps 4,5,6,7, and 8 on the opposite concrete side wall.

10. Check the tread marks on each wall to see that they are level with each other. If so, the riser marks will also check.

C. HOW TO INSTALL THE STRINGERS

1. Put 2 in. x 12 in. planks in position, so the under side of the plank just clears the nosing of each step as marked on the wall. See Fig. 1.

2. Cut in the two 2 x 4 braces and wedge the stringers tightly in position against the side walls.

3. Cut six pieces of 1 5/8 in. x 7 in. dressed plank to fit between the side walls. These are the riser forms.

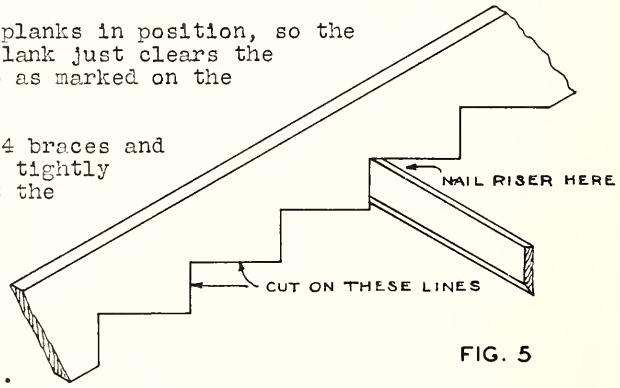


FIG. 5

CUT-OUT STRINGER

4. Bevel the bottom edge of each riser as shown in Figs. 1 and 2.

5. Nail short pieces of 2 x 4 to the stringers to provide a surface to which to nail the ends of the riser boards (Fig. 1). Keep the 2 x 4 cleats back, the thickness of the riser boards, from the riser marks on the side wall. The bottom end of the cleats should be about one inch above the tread mark on the side wall.

   NOTE: A cut-out stringer, such as shown in Fig. 5 may also be used for this type of stairs.

6. Nail the riser boards to the cleats, keeping the top and bottom edges of the riser boards even with the tread marks on the side wall.

7. Brace the stringers at the bottom so the weight of the concrete will not force them down (Fig. 1).

8. Check the tops of the riser boards to see if they are level. Recheck all members of the form to be sure they have not moved, or will not move from the pressure of the concrete.

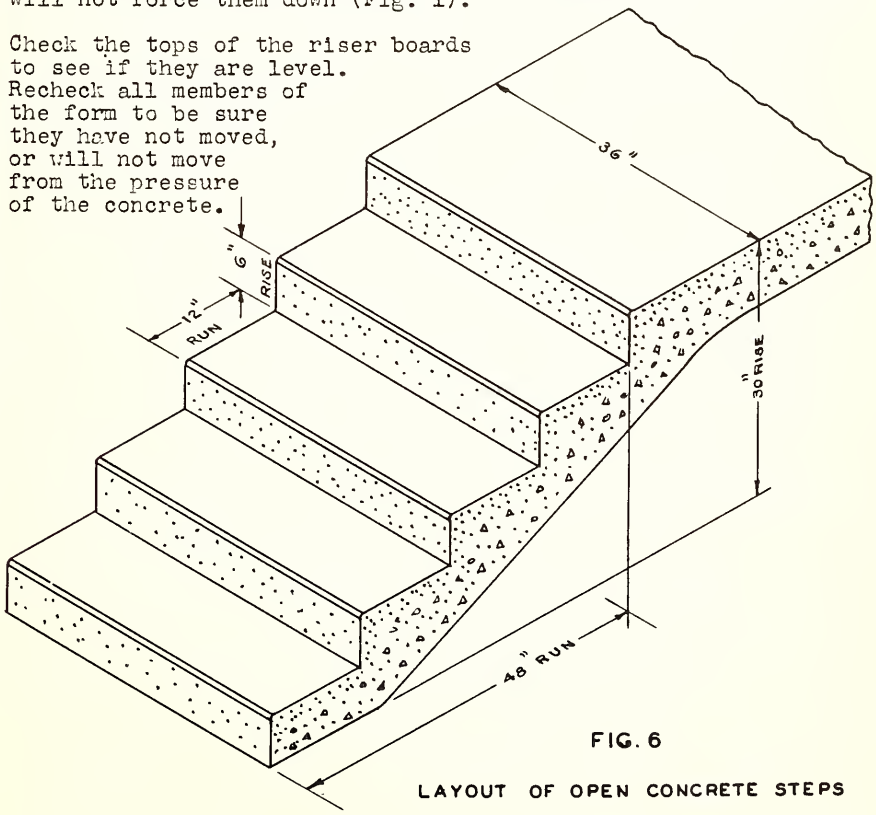


FIG. 6

LAYOUT OF OPEN CONCRETE STEPS

HOW TO BUILD OPEN STEP FORMS

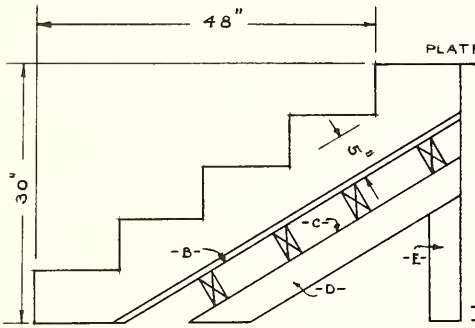


FIG. 7 LAYOUT OF FORM FOR OPEN STAIRS

NOTE: Figure 6 shows the open type of concrete stairs. The rise of each step is 6 in. and the total rise is 30 in. The treads are 12 in. and the total run is 48 in. from the face of the platform.

Lay out a full size drawing of the stairs on the floor (Fig. 7).

1. Lay out line B, Fig. 7, for the bottom of the sheathing.

2. Lay out line C. This is the top of the inclined member D, Figs. 7 and 8. From this line, the length and bevels of the inclined piece D can be obtained.

3. Cut two pieces D, and try them in place on the full size layout to see if they are correct.

4. Determine the length and bevel of the shore E, Figs. 7 and 8, and cut two of these.

5. Nail the pieces D and E together with cleats F as shown in Fig. 8.

6. Place the assembled horses squarely against the walls where the form is to be located.

7. Nail cross joists (Fig. 9) to the inclined tops of the horses with only enough nails to hold them in place. These pieces should project at least 14 in. on each side and should be spaced about 16 in. on centers.

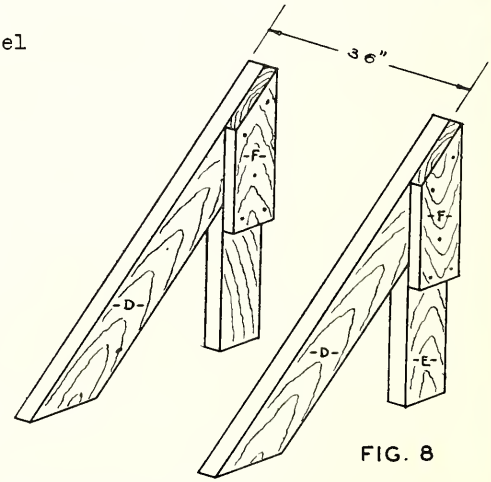


FIG. 8 SUPPORTING HORSES

8. Nail the sheathing in place to form the bottom of the stair soffit (Fig. 10). Lay the sheathing from each side to the center and put in the filler piece last. Short pieces can be used to advantage as shown.

9. Lay out and cut the pitch blocks (Fig. 11). Refer to Figs. 3 and 4 of this unit.

10. Nail the pitch blocks to a plank to form the stringer (Fig. 12).

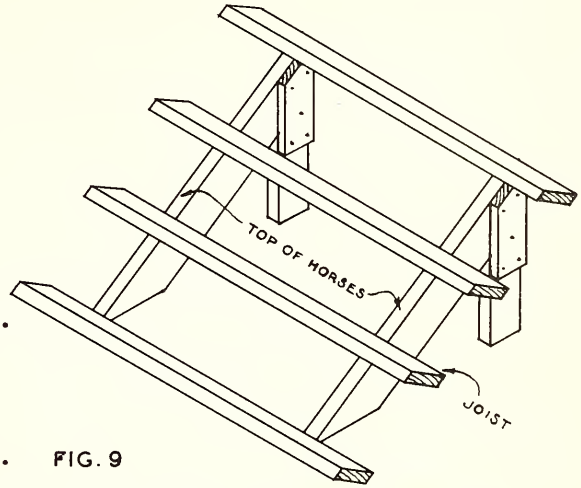
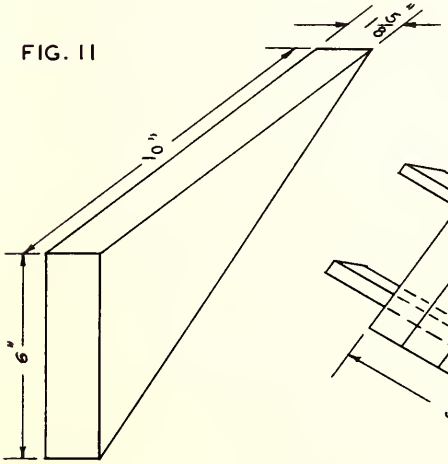


FIG. 9

CROSS JOIST NAILED ON HORSES

FIG. 11



PITCH BLOCK

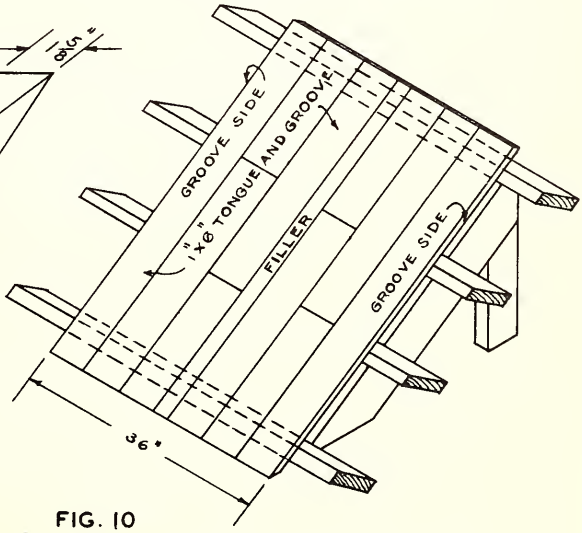


FIG. 10

SHEATHING NAILED IN PLACE

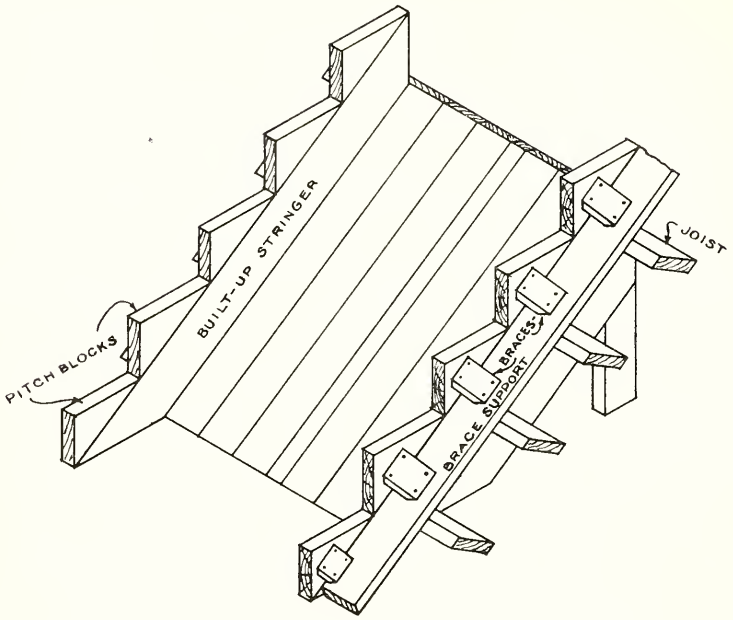


FIG. 12

STRINGERS IN PLACE

11. Place the built up stringer on each side of the form as shown in Fig. 12.

12. Nail 2 x 8 brace supports on both sides of the stairs as shown in Fig. 12. Do not drive these nails home.

13. Plumb the stringers of the stairs and put in braces from the brace supports to near the top of the pitch blocks on the built up stringer.

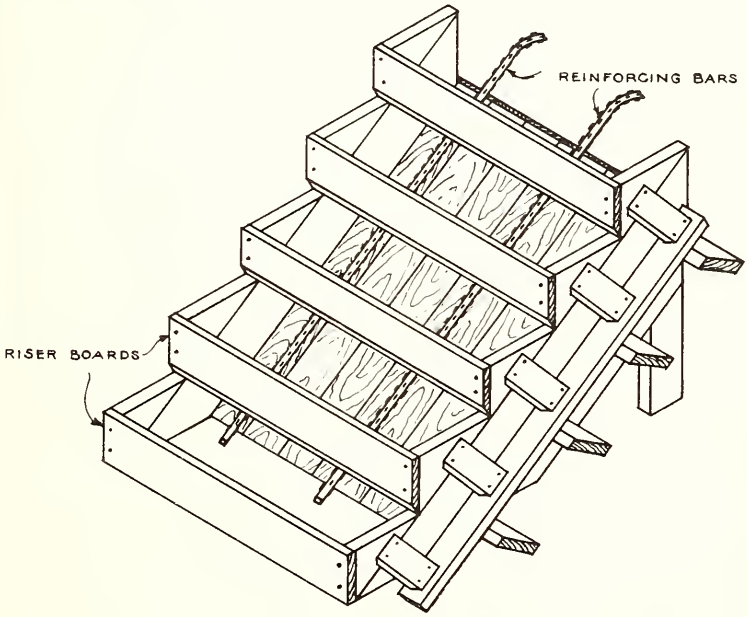
14. Cut the riser boards to length and width, and bevel them at the bottom edge. The bottom riser board need not be beveled.

15. Nail on the risers as shown in Fig. 13.

NOTE: On wide stairs, a hanging stringer is sometimes used in the center of the risers (Fig. 5, 1C-T28). This prevents the center of the risers from being pushed out.

6. Check the tops of the riser boards and the tread line of the pitch blocks to see if all are level. Secure the braces as explained for step forms built on sloping ground.

7. Place reinforcement rods 1 in. from the surface of the sheathing as explained in Unit 1C-T28.



FINISHED FORM FOR OPEN STEPS

FIG. 13

DESCRIPTION OF FORMS FOR FLOOR AND SIDEWALK SLABS

1. To describe the type of forms needed for concrete sidewalks and interior cellar floors.

2. To mention the important facts concerning the building of forms of this type.

INTRODUCTORY INFORMATION

It is sometimes the work of the carpenter to provide forms for concrete sidewalks and interior concrete floors. A general knowledge of this work is therefore important. Straight form work of this type is often done by the mason if the masonry work is sublet by the general contractor. If the masonry work is done by the general contractor, the form work is usually done by the carpenter.

CONCRETE FORMS FOR SIDEWALKS AND FLOORS

The forms for sidewalks are generally made of 2 x 4 stock. Only straight and sound stock should be selected. Long lengths should be used wherever possible, as the fewer joints there are in the form, the easier it will be to straighten it.

Forms for sidewalks and floors should be placed in such a way that the top edge of the form will act as a guide for the mason in finishing the top of the sidewalk or floor.

The forms should be made straight and true and properly sloped so as to provide drainage for the finished concrete surface. For drainage of sidewalk surfaces, the slope across the width of the sidewalk should not exceed $\frac{1}{4}$ in. for each foot of width. In cellar floors the amount of slope may be increased so that the floor surface will drain readily.

This type of form is braced by driving stakes into the ground on the outside of the form and nailing them to the form. Additional bracing may be necessary, especially if the bottom of the form does not rest solidly on the ground. In this case, gravel or earth may be used to form a solid bed for the form.

Concrete sidewalk slabs should have expansion joints to provide for the expansion and contraction caused by the heat of the sun and the cold of the winter. These joints are made by inserting a tapered piece of wood between the concrete panels as they are poured. They are placed so as to act as a guide for the concrete workers in forming the line between the panels of concrete when finishing the top

coat. After the finished concrete has partially set, the piece of tapered wood is pulled out of the concrete, and melted tar or a plastic caulking compound is run in the slot. This forms a water tight joint as well as an expansion joint for the concrete.

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How to Make Concrete and How to Use It...Portland Cement Association

Alpha Cement - How to Use It.....Alpha Portland Cement Co.

HOW TO BUILD FORMS FOR CONCRETE FLOORS AND WALKS

OBJECTIVES ON THE UNIT

1. To show how to make forms for walks and floors.
2. To show how to brace forms for walks and floors.
3. To show how to install an expansion joint between concrete slabs.

INTRODUCTORY INFORMATION

In making and setting forms for concrete walks and floors, it is essential that they be placed at the correct height so they will drain well and so they will meet ground levels, floors, steps, and walks properly.

TOOLS AND EQUIPMENT

Hammer
Crosscut saw
Chalk line
Level
Steel tape
Steel square
Straight edge
Stakes (1 in. x 2 in. x 15 in.)

PROCEDURE

HOW TO BUILD A FORM FOR A SECTION OF SIDEWALK 4 FEET WIDE AND 12 FEET LONG

1. Cut two pieces 2 in. x 4 in. x 12 ft. for the sides of the form.
2. Cut two pieces 2 in. x 4 in. x 4 ft. 3 1/4 in. for the two ends of the form. Cut two pieces 2 in. x 4 in. x 4 ft. for the spreaders. The extra 3 1/4 in. on the end pieces allows for a lap of 1 5/8 in. over each side piece at the ends of the form. See Fig. 1.
3. Place the side pieces in position and drive a stake into the ground near one end of the side piece (Fig. 1).
4. Determine the required elevation of the top of the sidewalk at this end. Mark this point on the stake and nail the side piece to the stake so that the top of the side piece coincides with the mark.
5. Level the side piece, or pitch it according to the drainage required for the sidewalk. Fasten the second end of the side piece to a stake.
6. Stretch a chalk line from one end stake to the other and align the edge of the side piece with the chalk line.

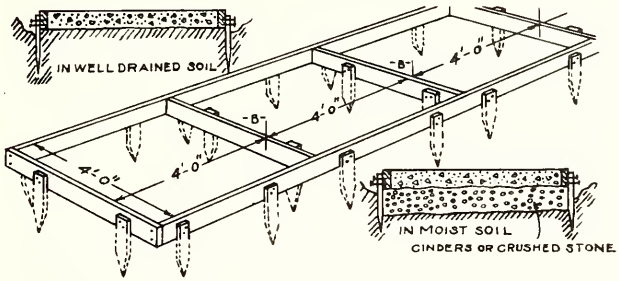


FIG. 1

FORMS FOR CONCRETE SIDEWALK

7. Drive stakes every 3 ft. along the side piece and nail them to it (Fig. 1).

8. Repeat the same procedure for the other side of the form.

9. To prevent the sides of the form from being crowded together, place the spreader pieces where the joints in the panels are to occur. These spreaders should remain between the sides until the coarse layer of concrete has been placed in the form.

10. Nail the end pieces of the form in position, keeping the top edges even with those of the sides (Fig. 1).

11. Test the top and side edges of the completed form with a straight edge and make any necessary adjustments.

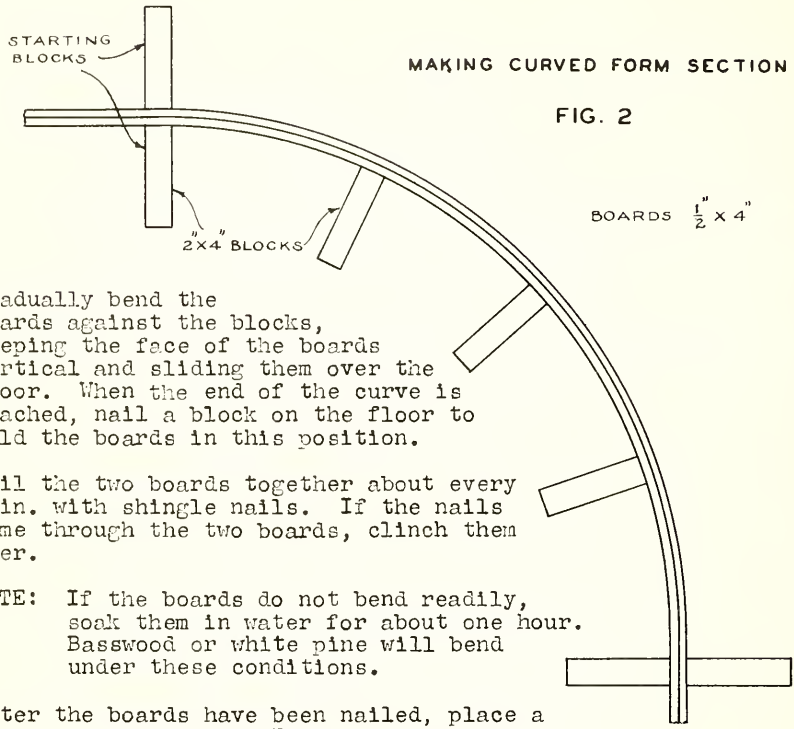
12. Pack earth around the outside and bottom edges of the form to keep it from moving if it is stepped on.

TO MAKE CURVED FORMS

1. Lay out the required arc or curve to full size. The subfloor of the building is a convenient place for this layout work.

2. If the arc or curve is large, toenail 2 x 4 blocks on edge, about 1 ft. apart along the curved line on the subfloor (Fig. 2).

3. Stand two pieces of 1/2 in. x 4 in. stock on edge on the floor and between the starting blocks shown in Fig. 2. These two boards should be longer than the curve. Nail the blocks solidly to the subfloor.



MAKING CURVED FORM SECTION

FIG. 2

4. Gradually bend the boards against the blocks, keeping the face of the boards vertical and sliding them over the floor. When the end of the curve is reached, nail a block on the floor to hold the boards in this position.

5. Nail the two boards together about every 6 in. with shingle nails. If the nails come through the two boards, clinch them over.

NOTE: If the boards do not bend readily, soak them in water for about one hour. Basswood or white pine will bend under these conditions.

6. After the boards have been nailed, place a cross brace on them. The blocks may be removed and the bent member placed in position in the form.

NOTE: If the curve is small, the piece may be cut from a solid piece of wood, or sheet metal or plywood may be used.

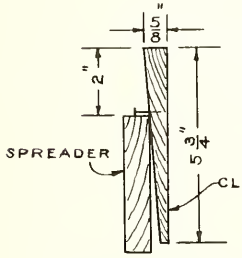


FIG. 3

EXPANSION JOINT SECTION

HOW TO PROVIDE FOR EXPANSION JOINTS

1. Cut pieces of 5 3/4 in. clapboards 4 ft. long.

2. Drive shingle nails 2 in. from the butt edge of the clapboards and hang them on the top of the spreaders to hold them at the proper height (Fig. 3).

NOTE: Sometimes special expansion joints are furnished by the mason.

NOTE: The forms for interior concrete floors such as cellar floors, are generally made in a similar manner as those for sidewalks, except that the expansion joints and panels are omitted. Straight edges are used to establish the top of the forms at the drainage points.

DESCRIPTION OF FORMS AND CENTERS FOR ARCHED OPENINGS

OBJECTIVES OF THE UNIT

1. To point out the function of arch centers.
2. To describe common designs for arched openings.
3. To describe the type of construction of forms for arched openings.
4. To point out uses of arched openings in house construction.

INTRODUCTORY INFORMATION

Arches of concrete, brick, or stone are used for door openings, cellar window areas and fireplaces, if it is necessary to support masonry above these openings. The masonry materials of which the arch is composed must be supported during the process of construction. Wooden forms called arch centers are built for this purpose by the carpenter. The arch center also acts as a guide to the mason. The centers may be removed after the mortar is thoroughly dry and the arch has become self-supporting.

Although there are many types and sizes of arch centers, only a few of the most common ones will be covered in this unit. The lay-out of the more complex types should be done by the architect.

TYPES OF ARCHES AND ARCH CENTERS

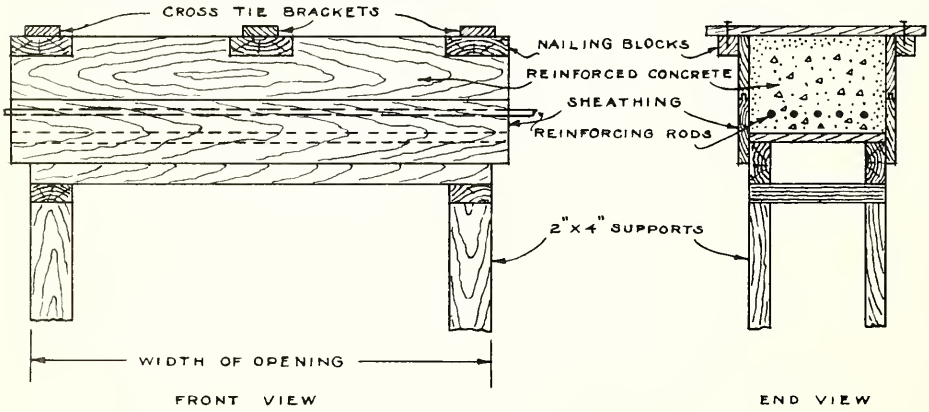
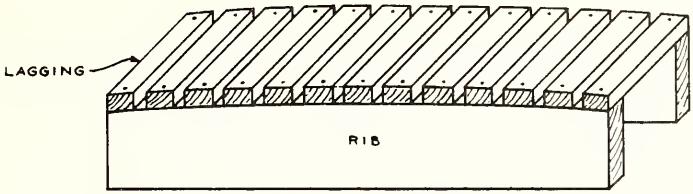


FIG. 1

FORM FOR REINFORCED CONCRETE ARCH



FLAT OR JACK ARCH

FIG. 2

A. THE FLAT ARCH

Figure 1 shows an arch center made for reinforced concrete. It consists of a box-like form supported over the width of the opening. The concrete is cast in this form.

For a masonry wall, the arch center is made as shown in Fig. 2. The lagging, generally consisting of 3/4 in. x 2 in. strips of wood, acts as a support for the masonry of the arch and as a means of holding the ribs together. The lagging is cut one inch shorter than the width of the masonry wall. This prevents the ribs of the arch center from interfering with the mason's lines. The ribs form the sides of the arch center and are cut to the shape of the arch.

Usually this type of arch has a slight crown or rise in the center so the arch will appear straight. If the arch is actually made straight, it will appear to be sagging in the center.

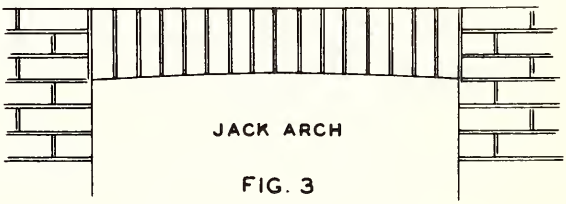
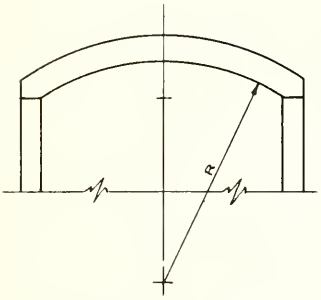


FIG. 3

Figure 3 shows the finished flat arch faced with a soldier course of brick. The brick is supported by an angle iron spiked on the outer rib of the arch center.

B. THE SEGMENTAL ARCH

The segmental arch is so called because it forms a segment of a circle. Figure 4 shows the layout of this arch. A rib of this type of arch center (Fig. 5) is made from a wide board, the top of which is cut to the desired curve. Lagging may or may not be

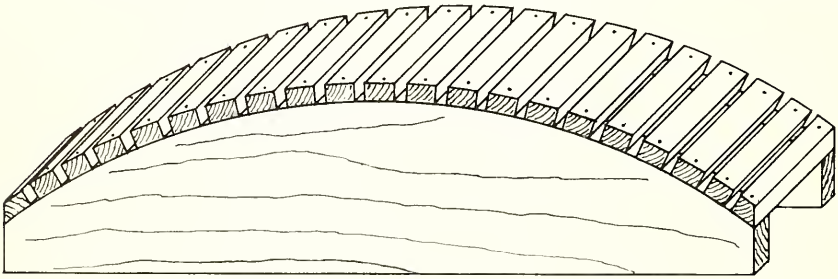


SEGMENTAL ARCH

FIG. 4

used, depending on the thickness of the masonry. If brick or stone veneer is to be supported, the two ribs of the arch center may be nailed to blocks which spread the ribs to within 1 in. of the thickness of the veneer. Figure 6 shows the finished arch after the center has been removed.

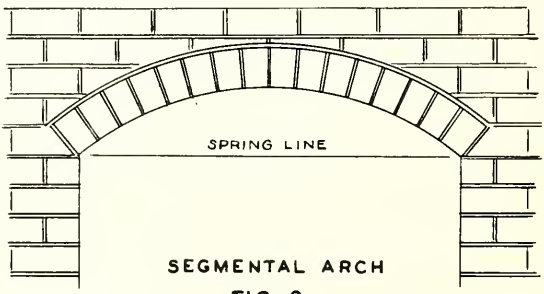
It is advisable to lay out arch outlines by geometrical construction on a large layout board or on the subfloor of the building. The carpenter should provide himself with a set of trammel points, and make a wooden beam on which to mount the points. The beam should be made long enough to mark the radius of the largest



SEGMENTAL ARCH CENTER

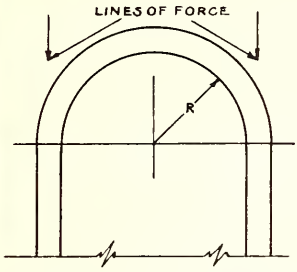
FIG. 5

arc encountered. Using the trammel points is a more accurate method than using a pencil and line. It is also more accurate than using a wooden rod with nails driven in each end, the distance between the nails representing the radius of the arc.



SEGMENTAL ARCH

FIG. 6



SEMI-CIRCULAR ARCH

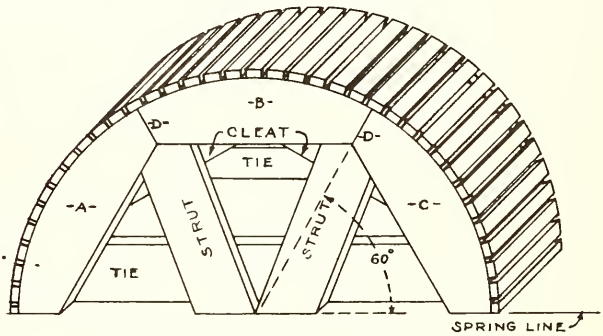
FIG. 7

C. THE SEMI-CIRCULAR ARCH

The semi-circular arch (Fig. 7) is perhaps the most common type. In a crowned arch of this type, the weight above the arch is diverted to the sides of the opening which act as supporting piers. The force on these side walls is both down and outward (Fig. 7). Therefore, the side walls of crowned arch openings must have solid side support

Since some of the semi-circular arch centers require many pieces of lumber to make the segmental parts, it is more difficult to lay out this kind of an arch than to lay out one that can be made from a solid board.

The outside edges of the segments A,B,C, Fig. 8 are cut to coincide with the circumference of the circle. The miter cut (D) is made on a radius of the circle. Cleats are fastened behind these three pieces to hold them together, and ties are used at the bottom to prevent the center from



PARTS OF AN ARCH CENTER

FIG. 8

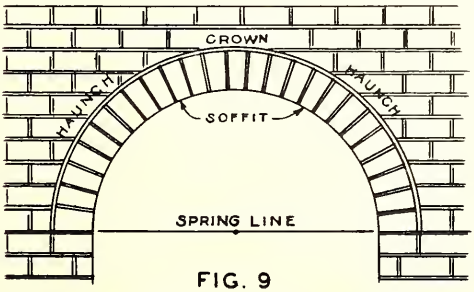


FIG. 9

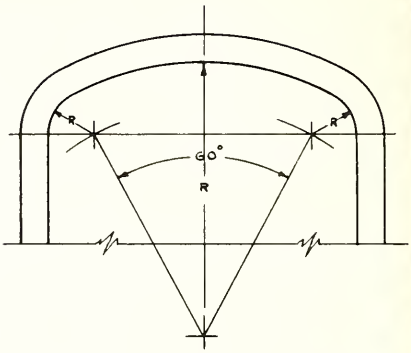
SEMI-CIRCULAR ARCH

spreading. In large arches, struts extending from the tie to the segments are used to help carry the load of the masonry. The entire piece is called a rib.

If the width of the jamb or wall is 4 in. or less, only one rib will be necessary. If the jamb is 4 in. to 17 in., two ribs should be used. Figure 9 shows the finished arch with the center removed.

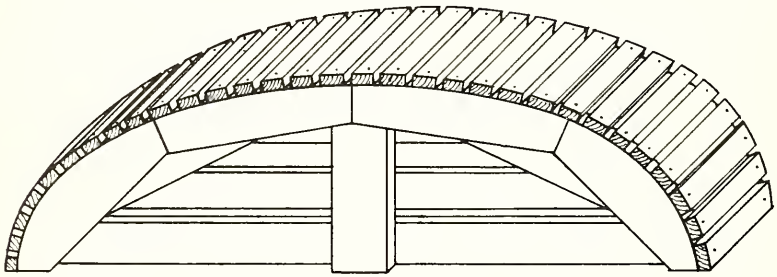
D. THE SEMI-ELLIPTICAL ARCH

This type of arch center is one half of an ellipse and is laid out as shown in Fig. 10. It is made somewhat like the semi-circular arch center but it is more difficult to construct because it requires a number of pieces to form the curve (Fig. 11). If the arch is wide and the masonry heavy, the cleats holding the segments together are made continuous on the back. Struts are used if the arch is over 3 ft. wide. These struts should be placed at the joints since they are the weakest points of the arch center.



SEMI-ELLIPTICAL ARCH

FIG. 10



SEMI-ELLIPTICAL ARCH CENTER

FIG. 11

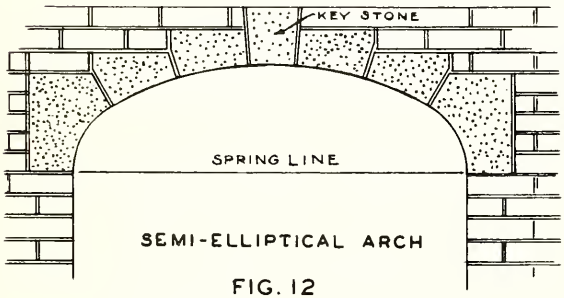


FIG. 12

The finished arch with the center removed is shown in Fig. 12.

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HOW TO LAY OUT AND BUILD CENTERS FOR ARCHED FORMS

OBJECTIVES OF THE UNIT

1. To explain how to lay out outlines for arched forms.
2. To show how to construct arch centers.
3. To show how to set forms for arches.

INTRODUCTORY INFORMATION

The carpenter generally uses rough stock to build arch centers. However, the accuracy of the work is important, because the arch centers are built and set in place before the masonry work is laid up. They should be made sturdy enough to support the weight imposed upon them, and should be made the proper size and shape so they coincide with the mason's heights and levels.

TOOLS AND EQUIPMENT

Hammer
Crosscut saw
Rip saw
Compass saw
Spoke shave
Plane
Rule
Steel square
Trammel points
Level

PROCEDURE

HOW TO BUILD THE FLAT OR JACK ARCH CENTER

NOTE: Assume that an arch center is to be built for a door opening 3 ft. 6 in. wide. The masonry wall is to be 1 ft. thick and the arch is to have a 1 in. rise.

1. Cut two pieces of stock 2 in. x 6 in. x 3 ft. 5 in. Square both ends of each piece.
2. Measure in from each end 20½ in. and square a line across the width of the board. This is the center line as shown at C, Fig. 1.

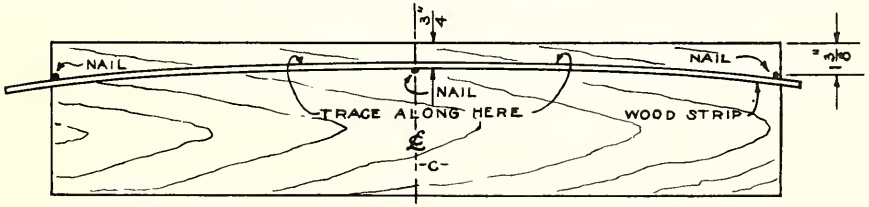


FIG. 1 - METHOD OF OBTAINING SLIGHT CURVE FOR RIB

3. Measure down from the top edge 1 3/8 in. at each end and drive a nail about half way in at these points.

4. On the center line (C, Fig. 1) measure down 3/4 in. from the top edge and drive a nail partly in at this point.

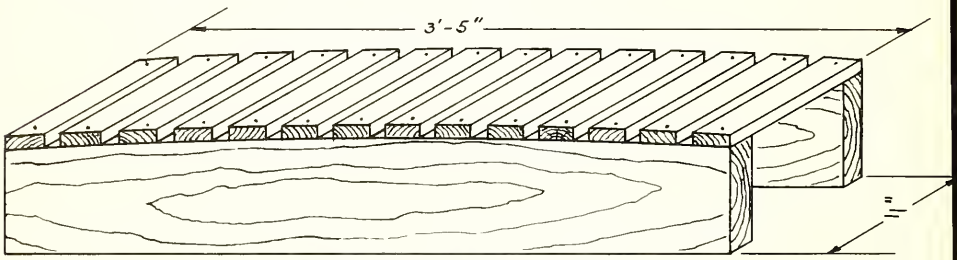
5. Procure a strip of wood 3/8 in. thick and about 4 ft. long.

6. Place and bend the strip of wood so it is against the three nails as shown in Fig. 1.

7. Mark a line along the strip, thus outlining the curve.

8. Lay out the other rib in the same manner and saw along the curved lines with a rip saw.

9. Square the ends of a 3/4 in. board to 11 in. long. Rip 2 in. wide lagging strips from this board.



ASSEMBLED ARCH CENTER

FIG. 2

10. Nail the lagging so the ends come flush with the outside face of each rib (Fig. 2). Space the pieces of lagging about 1 in. apart. Be sure the center is squared, and that a few of the pieces of lagging are double nailed at the ends so as to hold the center square.

NOTE: For the reinforced concrete flat arch, a box-like form is built to hold the wet concrete, as shown in Unit 10-T30, Fig. 1.

HOW TO BUILD A SEGMENTAL ARCH CENTER

Assume that the opening in a 12 in. wall is 24 in. wide and the rise of the arch center is to be 6 in.

1. Cut two pieces of stock 1 in. x 10 in. x 24 in.

2. Square a line across the center of one board.

3. Tack the board on the subfloor and, with the tongue of the framing square against an edge of the board and on the center line, project a line away from the board about 18 in. long (Fig. 3).

4. From a point (A) on the center line near the top of the board, measure down 6 in. along the center line to establish point B, Fig. 3.

5. From line AB, square a line across the board to locate point C.

6. Draw the line AC.

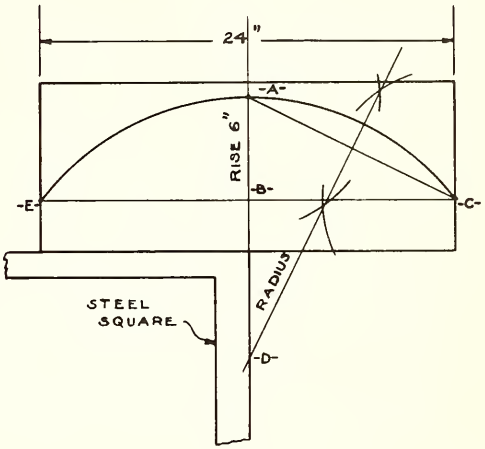


FIG. 3

LAYOUT OF SEGMENTAL ARCH

7. Construct a bisecting line, vertical to line AC, and extend it until it intersects the center line of the board at D.

8. Using AD as a radius, swing an arc EAC by means of the trammel points.

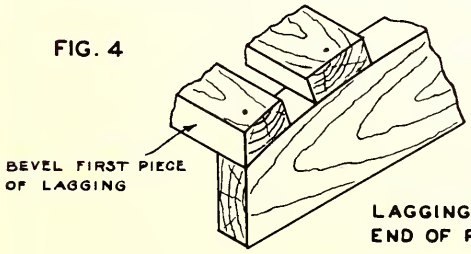
   NOTE: If lagging is to be used, the thickness of the lagging should be deducted from the length AD, thus making an arc with a smaller radius.

9. With a compass saw, cut on the line just marked.

10. Mark and cut the other piece.

11. Cut and nail on the lagging strips as explained for the jack arch center.

FIG. 4



NOTE: Bevel the end pieces of lagging slightly so the top edge will not project beyond the ends of the ribs (Fig. 4). The end pieces of lagging may also be kept back so the outside edge does not project beyond the end of the ribs.

HOW TO BUILD THE SEMI-CIRCULAR ARCH CENTER

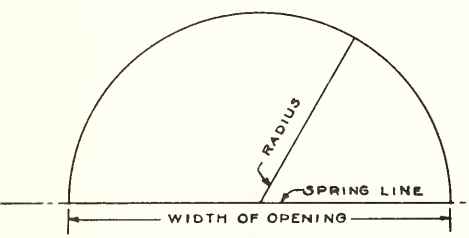


FIG. 5

LAYOUT OF SEMI-CIRCULAR ARCH

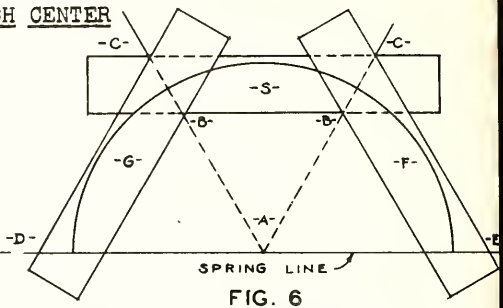


FIG. 6

MARKING CUTS ON SEGMENTS OF RIB

1. Lay out the curve of the arch with trammel points on the subfloor. Use a radius of one half the width of the opening minus the thickness of the lagging (Fig. 5).

2. Cut three pieces of wood and tack them to the floor over the arch mark (Fig. 6). The outside pieces (F and G) should be on top and the outside edge of each board should cover the curved line. The width of the boards where the angle cuts are to be made should be not less than 3 in.

3. Draw two straight lines from the center point A, Fig. 6, through the intersecting edges (C and B) of the boards. These lines show the miter cuts on the boards F and G. The line DE marks the bottom angle cuts on these same boards.

4. Make the cuts on both ends of boards F and G.

5. Re-set the pieces F and G and mark the top piece S.

6. Remove this piece and make the cuts on the ends.

7. Re-set the three pieces as at Fig. 7. Check to see that the three pieces are on the curved line and at the spring line.

8. Strike the arc on these pieces (Fig. 7). Cut along the curved line of each piece with a compass saw and finish with a spoke shave or plane.

9. Re-set each piece in place and nail cleats over the joints (Fig. 8). These cleats should be at least 16 in. long. Be sure they do not project above the top of the rib.

10. Cut a tie for the bottom (W, Fig. 8) and nail this to the two bottom segments (F and G). The ends of the tie should be slightly curved to match the curve of the segments.

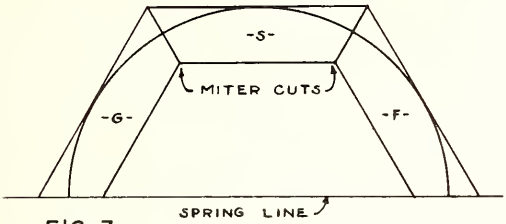


FIG. 7

LAYOUT OF SEMI-CIRCLE ON RIB

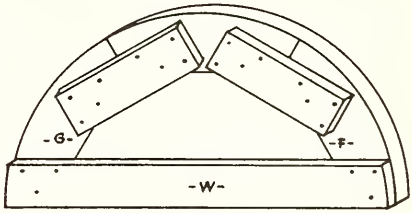


FIG. 8

CLEATS ON RIB

NOTE: If the center is over 4 ft. wide, it will be necessary to use struts. They should be inserted at the miter cuts where they will strengthen the weakest points of the rib.

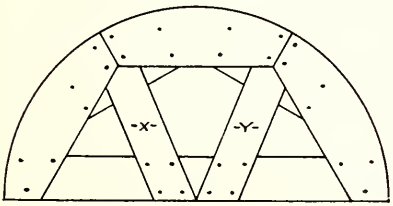
11. Turn the rib over and cut in the struts X and Y, Fig. 9. These can be nailed to the cleats and the tie. The other rib can be made in the same manner.

NOTE: Should it be necessary to build several arch centers of the same dimensions, make one rib, check it for accuracy, and then use this rib as a pattern for all ribs of all the arches. This same method should be followed in making the struts, lags, cleats, and braces.

12. Cut the required amount of lagging.

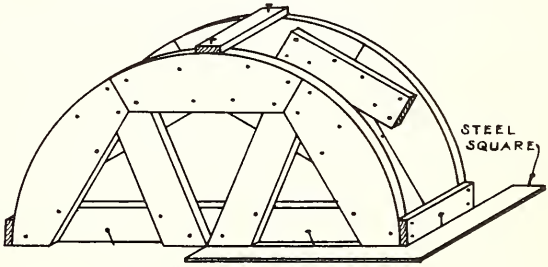
13. Tack the two ribs of the arch center to the floor (Fig. 10). Nail a piece of lagging across each end of the pair of ribs to space them the proper distance apart.

14. Tack one piece at the top temporarily, so the two ribs will be spaced correctly.



STRUTS ON RIB

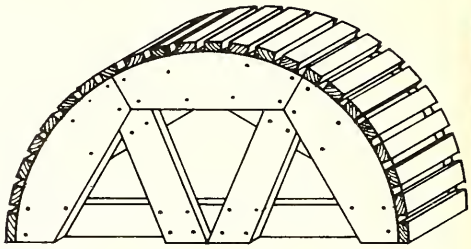
FIG. 9



ATTACHING LAGGING

FIG. 10

15. With a steel square, check the two ribs for squareness (Fig. 10) and make adjustments if necessary. Nail on the remainder of the lagging. Be sure that it is nailed square with the ribs. Figure 11 shows how the center should look when complete.



COMPLETED ARCH CENTER

FIG. 11

NOTE: The semi-elliptical arch center is made in much the same way as the segmental arch. However, the layout, which is shown in Unit 1C-T30, is different.

HOW TO SET ARCH CENTERS

NOTE: Figure 12 shows a doorway arch center set in place before the finished door frame is installed. Centers for window frames are sometimes set in conjunction with the window frames. In this case, the centers rest on the frames. If the frames have not been set, the centers will have to be supported by shores.

1. Cut four posts or shores long enough to support the center from the floor. See A and C, Fig. 12.

2. Set one of these shores upright against each corner of the opening as shown by A,B,C,D, Fig. 12.

3. Cut two pieces of 2 x 4 to the same length as the thickness of the masonry wall. See E and F, Fig. 12.

4. Nail the 2 x 4 plates on top of the shores. These act as ties for the shores and also as nailing surfaces for the arch center.

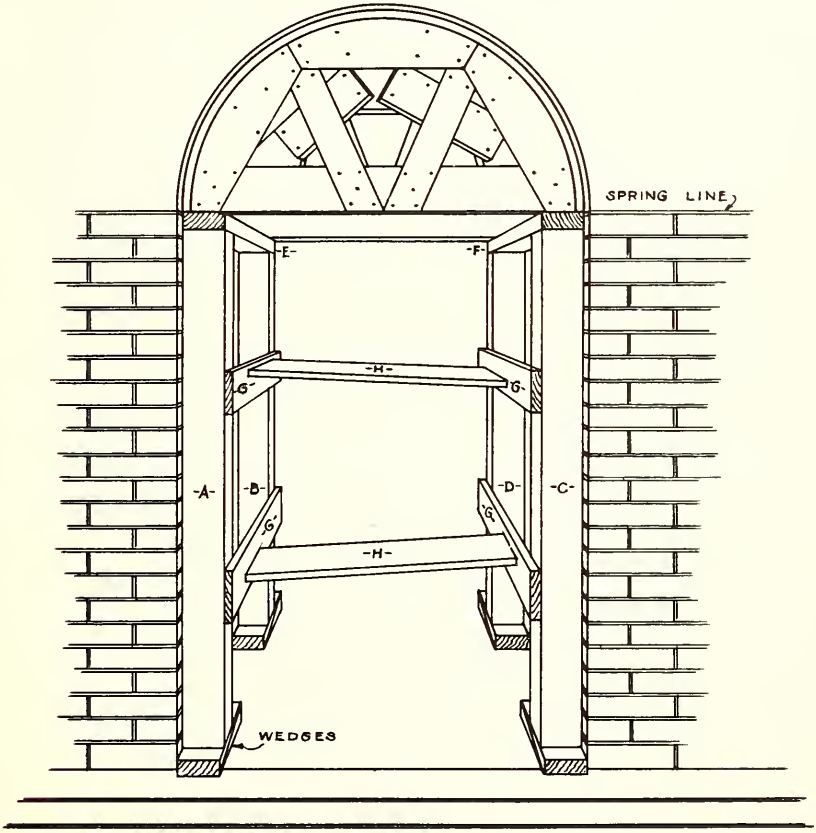
5. Cut four pieces 1 in. x 6 in. for cleats to tie and brace the shores (G, Fig. 12). Nail these in place.

6. Cut and place a pair of wedges under each shore. These are to be used to bring the top of the shores up to the spring line of the masonry arch, and to simplify the removal of the center after the mortar in the arch has set.

7. Cut two braces (H) to such a length that they will wedge the shores tightly against the sides of the opening. Toenail these in place.

8. Set the center in place and level it by adjusting the wedges at the bottom of the shores. Toenail the wedges and arch center in place.

NOTE: If there is any danger of the center tipping, nail a brace from the under side of the top lagging to the floor or shore post. Do not nail this brace to the scaffold as it would then move if workmen walked on the planks.



ARCH CENTER IN PLACE

FIG. 12

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